American Auditory Society Scientific and Technology Meeting
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POSTER ABSTRACTS

Topic areas and poster numbers:

Topic Area	Poster Numbers

POSTER SESSION –
Friday, March 5, 2021, 1:30 p.m. – 4:00 p.m. MST

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ANATOMY and PHYSIOLOGY

Poster #: 01

Evidence for a Shared Generation Mechanism of Reflection-Type OAEs
Mark Rinaolo; Courtney Glavin; Sumitrajit Dhar, Northwestern University, Evanston, IL

Objectives: Otoacoustic emissions (OAEs) are low-level sounds measured in the ear canal that originate in the cochlea. OAE types have traditionally been categorized by the stimulus/stimuli used to evoke them. However, more recent work suggests that there are two distinct classes of OAEs – distortion (nonlinear) and reflection (linear). It is theorized that emissions within a respective class share a common generation mechanism. While distortion emissions are thought to arise from nonlinear processes associated with outer hair cell transduction, reflection emissions are thought to arise from the back-scattering of energy due to irregularities, or “roughness”, along the cochlear partition. In this project, we explore two types of OAEs evoked using different stimuli but theorized to both be reflection-type emissions: stimulus-frequency OAEs (SFOAE) and the reflection component of distortion product OAEs (DPOAER). Specifically, we test the hypothesis that both are reflection-type emissions that arise from a common generation mechanism. We test this hypothesis by comparing the phase gradient delay of SFOAEs and DPOAER within ears. Similar phase slopes between both SFOAE and DPOAER would provide support for this hypothesis.

Design: SFOAE and DPOAE level growth functions were recorded from .5-14 kHz in one ear of 21 participants (9 male, 12 female, aged 18-42 years). All participants had normal behavioral Békésy tracking thresholds (based on normative data from our laboratory) from .5-14 kHz. SFOAEs were measured using a suppressor; the probe level varied from 25-55 dB FPL in 10 dB steps, while the suppressor was fixed at 70 dB FPL. DPOAEs were measured with L1 fixed at 60 dB FPL and L2 varied from 25-55 dB FPL in 10 dB steps. Prior to analysis, the estimated reflection component (DPOAER) was separated from the composite DPOAE using inverse fast Fourier transform (IFFT) with time-windowing. We extracted phase estimates from both SFOAEs and DPOAERs across test frequency with the goal of comparing phase slopes (i.e., change in phase across frequency) of both emissions.

Results: While data analysis is ongoing, we predict that SFOAE and DPOAER will have similar phase slopes. We will present average phase slopes as well as slopes from individual participants. As appropriate, we will also preliminarily explore additional factors that may influence these phase slope characteristics, including participant age and level of the evoking stimulus.

Conclusions: If our prediction is correct, these data will strengthen existing literature to further support the hypothesis that both OAEs are reflection-type and share a generation mechanism. We will discuss the existing literature in this area, the hypothesis suggesting how linear reflection OAEs are generated, and potential future directions (including clinical) for using reflection-type OAEs.

Poster #: 02

Early ABR Waveform Initiation is Influenced by Cochlear Nonlinearity

Shaum P. Bhagat, PhD, San Jose State University, San Jose, CA

Objectives: Human auditory brainstem response (ABR) computational models have relied on processing stages emphasizing cochlear compressive nonlinearities in order to improve the accuracy of model performance in predicting actual ABR waveform latencies from human data. The purpose of the current study was to formally examine the relationship between compression estimated from distortion-product otoacoustic emissions (DPOAE) and the absolute latencies of Wave I and Wave V in humans.

Design: The subjects were 12 adult normal-hearing human females aged 22-28 years. The experimental procedures used in the study were approved by the University of Memphis Institutional Review Board and all subjects provided written informed consent. DPOAE input-output functions (L2=25-75 dB SPL) were measured across a two-octave frequency range and were fitted with third-order polynomials to derive compression thresholds (CT) . Single-channel click-evoked ABRs were recorded differentially with disk electrodes placed at the high forehead location (~Fpz) referenced to an earlobe electrode ipsilateral to the stimulus ear with the ground electrode placed at the mid forehead. Each ABR waveform was constituted from 2000 averages. ABR waveforms were replicated to assist in accurate identification and labeling.

Results: DPOAE CT varied from 42-47 dB SPL on average and were relatively constant at 1000, 2000, and 4000 Hz. Individuals with low CT at 4000 Hz exhibited longer ABR Wave I latencies while individuals with high CT at 4000 Hz exhibited shorter ABR Wave I latencies, and this relationship was statistically significant ($r = -0.68$, $p=0.01$). No statistically significant relationships between DPOAE CT and ABR Wave V absolute latencies were detected.

Conclusions: The parallel hallmarks of cochlear amplification when the amplifier is in good condition are narrowly- tuned cochlear filters and compressive growth functions. According to filter theory, the build-up and processing times in narrowly tuned cochlear filters result in longer output delays and briefer output delays would be expected in more broadly tuned cochlear filters. The linkage between CT at 4000 Hz and ABR Wave I latency in the present study provides indirect evidence of enhanced cochlear tuning in individuals with low CT compared with individuals with high CT. These findings are consistent with known cochlear amplifier characteristics and complement previous results indicating that individuals with low CT exhibit better hearing thresholds than individuals with high CT.

Poster #: 03

Cochlear Amplifier Exhibited Significant Individual Differences in Both 129S6/SvEv and CBA/Caj Inbred Mice Strains: Revealed through Distortion Product Otoacoustic Emission (DPOAE)
Li Yang, MS; Ishan Bhatt, PhD, The University of Iowa, IA; O'neil Guthrie, AuD, PhD, Northern Arizona University, Flagstaff, AZ

Objectives: Dampened DPOAE output has been used as a diagnostic marker for hearing loss. Interestingly, a variation of DPOAE outputs has also been observed in populations with normal hearing. A previous study has shown that these variations coordinate with genomic polymorphism. This is reasonable, as genomic disposition provides a template for structural proteins that determine cochlear functions. Therefore, we hypothesis that DPOAE outputs will be different between subjects who share different genomic disposition, and similar between subjects who share the same genomic disposition.

Design: Here, we tested DPOAE in young inbred mice strains: 129S6/SvEv and CBA/Caj, as these two mice strains have demonstrated differences in genomic disposition.

Results: We found that DPOAE outputs were significantly lower in the 129S6/SvEv mice relative to the outputs in the CBA/Caj mice. Interestingly, we have also found significant individual differences within both 129S6/SvEv and CBA/Caj mice strains.

Conclusions: These results indicate that the underlying genomics is necessary but not sufficient to determine cochlear nonlinearity. Future studies on other factors like epigenetics might shed more light on the underlying mechanisms for the prevalence of cochlear individual differences.

Poster #: 04

New Investigator Poster Award

Dichotic Listening Deficits in Amblyaudia are Characterized by Aberrant Neural Oscillations in Auditory Cortex
Sara Momtaz Bokharaei; Deborah Moncrieff, PhD; Gavin Bidelman, PhD, University of Memphis, Memphis, TN

Objectives: Children diagnosed with auditory processing disorder (APD) show deficits in processing complex sounds that are associated with difficulties in higher-order language, learning, cognitive, and communicative

functions. Amblyaudia (AMB) is a subcategory of APD characterized by abnormally large ear asymmetries in dichotic listening tasks. Here, we examined frequency-specific neural oscillations and functional connectivity via high-density electroencephalography in children with and without AMB during passive listening of nonspeech stimuli.

Design: Time-frequency maps of these “brain rhythms” revealed stronger phase-locked _/_ (~35 Hz) oscillations in AMB participants within bilateral auditory cortex for sounds presented to the right ear, suggesting a hypersynchronization and imbalance of auditory neural activity.

Results: Brain-behavior correlations revealed neural asymmetries in cortical responses that predicted the larger than normal right-ear advantage seen in participants with AMB. Additionally, we found weaker functional connectivity in the AMB group from right to left auditory cortex, despite their stronger neural responses overall.

Conclusions: Our results reveal abnormally large auditory sensory encoding and an imbalance in communication between cerebral hemispheres (ipsi- to -contralateral signaling). We suggest these neurophysiological changes might lead to functionally poorer behavioral capacity to integrate information between the two ears in children with AMB.

AUDIOLOGY / OTOLOGY

Poster #: 05

Measuring Basal OAE Sources in Young-Adult and Older-Adult Ears
Courtney Glavin, AuD; Sumitrajit Dhar, PhD, Northwestern University, Evanston, IL

Objectives: Otoacoustic emissions (OAEs) are byproducts of active processes within the cochlea measured as low-level sounds in the ear canal in response to an evoking stimulus. Traditionally, OAEs have been thought to arise from a relatively small spatial region within the cochlea that corresponds to the frequency of the evoking stimulus/stimuli (f2 or fp). However, recent evidence suggests that cochlear sources basal (i.e., towards the cochlear base) to f2/fp may contribute to the measured OAE. This exciting development has significant potential implications for interpreting OAE patterns both in the laboratory and in the clinic.Nevertheless, the presence of basal sources has only been demonstrated in young, healthy human ears at high stimulus levels. Many key questions remain, including whether basal sources contribute to OAEs in aged ears. This is a particularly important question because basal regions of the cochlea are first affected in the natural aging process. Thus, the relative contributions of basal sources to OAEs may change as a function of age. We explore this phenomenon here.En route to a larger study examining OAEs and aging, the objectives of this pilot experiment are to: 1)Assess a paradigm for measuring basal source contributions in OAE growth functions in humans 2)Examine potential basal contributions across age groups (18-22 vs. 30-40 years) and OAE types (distortion product OAEs vs. stimulus-frequency OAEs).

Design: We will measure DPOAE and SFOAE level growth functions with and without a basal suppressor. The differences between growth functions in these conditions will quantify potential basal source contributions. Multiple basal suppressor paradigms will be assessed (e.g., changing suppressor level, type, or frequency re: probe) to better suppress potential basal sources, and/or to avoid interactions with the probe We will do this in two age groups. The younger group (18-22 years) will serve as a baseline group. The older group (30-40 years) was selected based on previous work from our lab, suggesting subclinical cochlear aging begins in the 30s. All

participants, regardless of age, will have clinically normal hearing (≤ 25 dB HL from .25-8 kHz). Though data collection has been limited due to the COVID-19 pandemic, our goal is to assess a minimum of five ears in each age group.

Results: Data collection is ongoing. However, preliminary results suggest that DPOAE levels decline with the addition of a basal suppressor at 4 kHz. These declines increase with increasing stimulus level. We will present additional results, including measurement paradigms for assessing basal source contributions to OAEs in human ears. We will quantify basal contributors to DPOAEs and SFOAEs in young and aged ears.

Conclusions: Preliminary data suggest that basal sources contribute to human DPOAEs at the frequencies evaluated thus far, with greater contributions as stimulus level increases.We will present and discuss additional results, with a focus on the implications of interpreting OAE patterns in human ears in the context of basal sources.

Poster #: 06

Accuracy and Test-retest Reliability of In-clinic and Remote In-situ Audiometry
Lisa Standaert, AuD; Anne Miller, AuD, Sonova, Aurora, IL

Objectives: In-situ audiometry allows clinicians to measure hearing thresholds directly through a client's hearing aids. This poster will present results on the accuracy of in-situ audiometry, assessed during in-clinic visits and performed remotely. The study was completed by the Phonak Audiology Research Center in May 2020. The focus of this study was to evaluate frequency-specific differences in audiometric thresholds obtained in the clinic to in-situ thresholds measured remotely (in the home) using AudiogramDirect in adults with mild to severe hearing loss. A default hearing aid fitting using the clinical audiometry was compared to a default fitting using AudiogramDirect audiometry. Participants subjectively compared a default hearing aid fitting using clinical audiometric thresholds to a default fitting using their own AudiogramDirect thresholds. Additionally, a retrospective data analysis of more than 150,000 in-clinic assessments of in-situ audiometry was performed and a study was set up investigating its remote equivalent.

Design: For the remote in-situ audiometry study, we recruited twenty-four experienced adult hearing aid users with a recent clinical audiogram on file. Remote support enabled receiver-in-canal (RIC) hearing aids were shipped to the participants' homes, and participants were instructed to install the myPhonak app on their personal smartphone or tablet. Participants were seen remotely via Phonak Target remote support and completed the AudiogramDirect testing on two separate occasions. Spontaneous acceptance of both the initial preprogrammed fitting and the fitting based from the AudiogramDirect results was collected. For the retrospective data analysis, we compared air conduction hearing thresholds obtained through in-situ audiometry (using Phonak AudiogramDirect) to those obtained by standard audiometry during the same in-clinic appointment for a large cross-sectional sample of 167 722 fittings.

Results: Both the retrospective analysis and the remote in-situ study showed a high level of agreement between hearing thresholds obtained through in-situ audiometry and standard audiometry.Thresholds obtained via AudiogramDirect as part of a remote session closely matched those thresholds that had been obtained in a face-to- face clinic visit. The mean differences were within +- 5dB at all frequencies with the exception of 250Hz and 500Hz. AudiogramDirect thresholds at these two frequencies were significantly higher, likely due to coupling differences between clinical insert earphones and RIC devices. Furthermore, participants did not notice significant differences between a fitting using their clinically obtained thresholds and a hearing aid fitting

using AudiogramDirect obtained thresholds, even when lower frequencies obtained via AudiogramDirect were poorer than their actual threshold. For the retrospective study, the mean difference between the two audiometric methods was smaller than ±5dB HL. The differences between both in-clinic methods lied within an interval of ±24 dB HL for 95% of the data. The results were frequency dependent, with a trend towards lower variation for middle frequencies.

Conclusions: AudiogramDirect can be used reliably, both in the clinic, and as part of a remote support session to measure a patient's hearing thresholds, when a clinical audiometer is not available and / or for the purposes of programming hearing aids. While an initial hearing aid fitting is ideally done during a face-to-face clinical visit, at times when this is not possible, fitters can rely on thresholds obtained via AudiogramDirect to program an initial fitting. Any fine tuning that is necessary is likely to be minimal, and typical of any other initial fitting. Although remote, in-situ audiometry may be a useful tool for fitting hearing aids, it should not be used as a replacement for an in-clinic assessment for diagnosing a hearing loss.

Poster #: 07

Effects of Effusion Volume on Hearing and Wideband Acoustic Immittance

Sarah Al-Salim, AuD; Richard Tempero, MD, PhD; Hannah Johnson; Lauren Crowther, BS; Denis Fitzpatrick, PhD; Stephen Neely; Gabrielle Merchant, AuD, PhD, Boys Town National Research Hospital, Omaha, NE

Objectives: The objective of this work is to determine whether there is a systematic effect of effusion volume on behavioral and physiologic audiological measurements in children with surgically-confirmed otitis media with effusion, including hearing and wideband acoustic immittance.

Design: Fifty-one ears from children aged 8 months to 11 years who had a diagnosis of otitis media with effusion and were scheduled for tympanostomy tube placement were recruited from medical clinics. The control group, recruited from a research volunteer database, consisted of 17 ears from children aged 10 months to 11 years without a recent history of otitis media. Participants received an audiologic testing battery consisting of tympanometry, otoacoustic emissions, audiometric thresholds, auditory brainstem response, and wideband acoustic immittance. In children with otitis media, this occurred on the day or two before surgery. On the day of surgery, wideband acoustic immittance testing was repeated in the pre-operative waiting room, and effusion volume was characterized by the surgeon during tympanostomy tube placement. Audiologic outcomes and wideband acoustic immittance (absorbance) responses were grouped and analyzed based on effusion volume: full effusions, partial effusions, ears clear of effusion at the time of surgery, and healthy normal control ears.

Results: Effusion volume effected the audiologic results and absorbance in a systematic manner. Ears with full effusions had moderate hearing losses, few to no measurable otoacoustic emissions, and delayed Wave V latencies. Ears with partial effusions and clear ears both had slight to mild hearing losses and normal Wave V latencies, though ears with partial effusions had fewer measurable otoacoustic emissions than clear ears. Absorbance was found to be systematically reduced at most frequencies as the volume of the middle-ear effusion increased, but the greatest reduction was observed in the range of 1-5 kHz. A multivariate logistic regression approach was utilized to classify absorbance responses from ears based on effusion volume and classified ears as effusion present (full and partial ears) or absent (clear ears and healthy normal control ears) with 100% accuracy, ears with effusion present as either partial or full with 100% accuracy, and ears without effusion as either normal control ears or ears clear of effusion with 75% accuracy. Regression performance was also explored when the dataset was split into a training set and a validation test set to simulate how this approach would perform on unseen data in a clinical setting. Overall, this approach demonstrated high

sensitivity and specificity for classifying ears as effusion being present or absent and as present effusions being full or partial effusions with areas under the curve ranging from 1 to 0.944.

Conclusions: Volume of a middle-ear effusion in children with otitis media with effusion has a systematic effect on the outcomes of a range of behavioral and physiological audiologic tests. As the volume of an effusion increased, so did the degree of hearing loss. Wideband acoustic immittance, and more specifically, absorbance, is a strong and sensitive indicator of the effusion volume and its ability to differentiate effusion volumes could provide valuable insight into the hearing status of a child.

Poster #: 08

Characterizing Distortion-Product Otoacoustic Emission Levels at Extended-High Frequencies across Age

Cailyn Kern, San Diego State University, San Diego, CA
Sky McIntyre, BA, San Diego State University, University of California San Diego, San Diego, CA
Gayla L. Poling, PhD, Mayo Clinic Rochester, Rochester, MN
Jonathan Siegel, PhD; Sumitrajit Dhar, PhD, Northwestern University, Evanston, IL
Laura Dreisbach Hawe, PhD, San Diego State University, San Diego, CA

Objectives: Distortion product otoacoustic emissions (DPOAEs) are an indicator of cochlear health. When extended-high frequency stimuli (EHF; >10 kHz) are used, DPOAEs can reflect inner ear damage that may be unseen at conventional frequencies as damage initially occurs at the basal end of the cochlea. The purpose of this study is to characterize EHF DPOAEs taking into account factors such as age, stimulus level, sex, and ear. This is an important step toward establishing normative DPOAE data using EHF stimuli.

Design: The population included 221 females and 131 males ranging in age from 10 to 65 years with normal hearing thresholds (<20 dB HL through 4 kHz) who were retrospectively evaluated using data obtained from the Hearing Assessment Reformulation Project (HARP) collected at Northwestern University. Five age categories were defined: 10-21, 22-35, 36-45, 46-55, and 56-65 years. DPOAEs were elicited at f2 frequencies of 10 through 16 kHz with a stimulus ratio (f2/f1) of 1.22 and low, mid, and high stimulus level (L1/L2) combinations (55/40, 65/50, 75/75 dB SPL, respectively). Measurements were made monaurally (ear chosen at random) utilizing a depth-compensated in-ear calibration procedure.

Results: Group and individual EHF DPOAE level data for the defined age groups and stimulus levels were determined. Collapsed across frequency, mean DPOAE levels decreased with increasing age and decreasing stimulus levels. When frequencies are examined independently, DPOAE levels vary for each age group and stimulus level combination. For example, with mid-level stimulation the mean DPOAE level for the 10-21 year olds at 10 kHz was -0.23 compared to -3.8 dB SPL at 16 kHz. Whereas, mean DPOAE levels for 56-65 year olds at 10 kHz was -10.41 compared to -16.64 dB SPL at 16 kHz. Low-level stimuli resulted in the fewest measurable DPOAEs, especially in the older age groups, while high level stimuli yielded the greatest numbers of measurable DPOAEs for all age groups. Despite the fact that males had greater mean levels from 10-12.5 kHz whereas females had greater mean levels from 12.5-16 kHz, overall DPOAE levels for males and females appeared similar. Mean DPOAE levels also were comparable between ears.

Conclusions: Mean DPOAE levels decrease with increasing frequency and fewer older individuals have interpretable data at the higher frequencies for all stimulus level combinations. However, DPOAE levels remain relatively constant through 12 kHz for younger age groups then decrease with increasing frequency, while older

age groups show a constant gradual decline in DPOAE level with increasing frequency. Age and stimulus level have a significant influence on the range of measurable DPOAE levels across extended-high frequencies, whereas the influence of sex and ear do not appear significant. Evidence supports that age of the individual and stimulus levels are key considerations for clinical applications of EHF DPOAE measures.

Poster #: 09

Can Smartphone Audiometry be Useful as a Diagnostic Tool?
Avia A Lowe, BS; Lata Krishnan, PhD, Lafayette, IN

Objectives: According to the World Health Organization, 4.32 million persons worldwide experience disabling hearing loss. Across the globe, many individuals with hearing loss, particularly in low- and middle-income countries (LMICs) and in rural communities in high-income countries reside in environments without access to hearing healthcare. Without access to early identification and intervention, disabling hearing loss can negatively impact the quality of life. In recent years, smartphone apps have become an option to reach individuals without access to hearing healthcare. The purpose of this project is to evaluate whether smartphone audiometry is an effective option for diagnostic hearing assessment of individuals without access to a clinic.

Design: A review of literature was conducted to evaluate peer reviewed literature on smartphone audiometry and compare the literature to evidence-based practice protocols. Articles were selected from credible search engines such as the Purdue University Libraries, Google Scholar, American-Speech-Language- Hearing Association journals, National Center for Biotechnology Information, and PubMed. Keywords included "Mobile phone audiometry, smartphone audiometry, audiometry app, rural community hearing testing, hearing health, hearing loss, and mHealth". Articles only discussing hearing screening were excluded from this review.

Results: Smartphone audiometry currently does not meet the standards for diagnostic audiological assessment, as is necessary for the fitting of amplification or for medical treatment referral.

Conclusions: While smartphone audiometry cannot be used as a diagnostic tool, it still has value as a screening tool for identification of possible hearing loss, and research is underway to expand the utility of smartphone audiometry to make it a valuable diagnostic tool.

Poster #: 10

Correction Factor Methods for Threshold Estimation Using ABR Testing
Emily Jo Casson, BA, Purdue University, Indianapolis, IN
Jillian Hubertz, AuD; Shannon VanHyfte, AuD, Purdue University, West Lafayette, IN

Objectives: The purpose of this study was to (1) investigate trends in correction factors currently being used by practicing audiologists to estimate audiometric thresholds in dBeHL from ABR thresholds obtained in dBnHL in infants, and (2) compare the trends to the current best practice recommendations from available literature. We hypothesized that (1) most clinicians use the constant correction method, but (2) apply a wide variety of correction factors for that method.

Design: A Qualtrics survey was created to gather information on correction factor methods, specific correction factors for different ABR stimuli, as well as demographic data including work setting, years of education, and

years of experience. The survey was distributed electronically to those currently performing ABR evaluations on infants; the main form of distribution was via email to the Early Hearing Detection and Intervention (EHDI) coordinators for each state. The survey was posted to professional organization groups, social media groups for audiologists, and emailed to the following individuals: coordinators for Hear Indiana, Purdue University clinical faculty, and Purdue AuD graduates from the past 10 years. A total of 76 individuals comprehensively completed the survey.

Results: The survey results indicated the method of constant corrections is most widely used, based on participant responses. However, the specific correction factor value applied differed across frequency, stimuli, and clinician.

Conclusions: The study determined there is no standard for applying correction factors to ABR thresholds in order to estimate audiometric thresholds in infants. Multiple correction factor methods are described in the literature, and the survey revealed a variety of correction factors currently being used in the field. This variability may be caused by differences in equipment and calibration. Clinically, correction factors provide estimates of behavioral hearing thresholds, which are used in the programming of hearing aids for infants until reliable behavioral results can be obtained. Further research is needed to determine if the use of different correction factors has a significant impact on audibility of sound and patient outcomes with amplification.

Poster #: 11

Ipsilateral Wideband and Single-Frequency Acoustic Reflex Thresholds in Adults

Jingjiao Jiang, BS; Xiao-Ming Sun, PhD, Wichita State University, Wichita, KS

Objectives: Clinical AR measurements have been applied in audiology for decades to help diagnose pathologies in the auditory system, but some limitations have concerned clinicians. In AR testing, a single pure tone (e.g., 226-Hz and 1000-Hz) is used as the probe signal. Wideband acoustic reflex (WAR) is a newly developed technique, utilizing wideband signals (clicks or chirps) as the probe, which includes a broad range of frequencies (e.g., 226 to 8000 Hz). A few early studies showed some advantages of the WAR procedure and its potential for clinical use. It is warranted to systematically compare it with the existing clinical procedure. The objectives of this study were to measure ipsilateral WAR thresholds (WART) using five activators and to compare with ipsilateral AR thresholds (ART) tested with two probe tones in the same ears.

Design: Data were collected from 31 adults aged between 18 and 28. All participants met stringent subject inclusion criteria (e.g., a single-peak 226-Hz tympanogram with the TPP between ± 25 daPa, air-conduction audiometric thresholds< 20 dB HL for octave frequencies from 250 to 8000 Hz and air-bone gaps< 10 dB from 500 to 4000 Hz). One ear was randomly selected as the test ear for each participant. The AR test was performed with a GSI TympStar tympanometer. A Wideband Tympanometry Research System (Interacoustic) was used for WAR tests. ARTs were tested with 226-Hz and 1000-Hz probe tones. They were determined by a repeatable change of ≥ 0.03 mmho and of ≥ 0.13 mmho in acoustic admittance, respectively. WARTs were automatically determined by the system, which included a low frequency (380-2800 Hz) and a high frequency (2800-8000 Hz) measure. For both tests were used five activators: tone bursts (500, 1000, 2000, and 4000 Hz) and broadband noise (BBN). The activators were presented in a randomized sequence.

Results: Median ipsilateral WARTs ranged from 85 to 90 dB SPL for the four tonal activators and were 60 dB SPL for BBN, and median ipsilateral ARTs ranged from 96 to 102 dB SPL for tone activators and were 85 dB SPL for BBN. The low-frequency WARTs were ~8 to 12 dB lower than ARTs with 226 Hz for tonal activators

and 19 dB lower for BBN ($p<0.05$, paired t-test). The ARTs with 226 Hz and 1000 Hz probe tones were not significantly different (about 1 dB) for all activators ($p>0.05$, paired t-test). The differences (3.2 to 6.5 dB) between low-frequency and high-frequency WARTs were not significant ($p>0.05$, paired t-test).

Conclusions: The current research has provided ipsilateral WART normative data in adults tested with all commonly used activators. The WARTs are significantly lower than single-frequency ARTs for all activators. The substantial differences (8 to 19 dB) could be clinically meaningful. Our results indicate that the WAR procedure is more sensitive than the AR in testing the middle-ear muscle reflex. The WART test efficiently compensates for restrictions of ART tests in clinical populations. It could be helpful in patients with absent acoustic reflex when tested using the AR procedure due to hearing loss.

Poster #: 12

Hearing Screening in Individuals with Dementia: A Scoping Review

Fiona Höbler, MS, KITE-Toronto Rehab, University Health Network, Toronto, ON, Canada
M. Kathleen Pichora-Fuller, PhD, Department of Psychology, University of Toronto, Mississauga, ON, Canada
Walter Wittich, PhD, School of Optometry, Université de Montréal, Montréal, Québec, Canada
Katherine S. McGilton, PhD, Lawrence S. Bloomberg, Faculty of Nursing, University of Toronto, Toronto, Canada

Objectives: Untreated hearing impairment becomes more prevalent with age, is positively associated with cognitive deterioration, can result in challenges in communication and social interaction, and lead to isolation and consequent depression in older adults. In long-term care (LTC) settings, the majority of residents are living with some degree of sensory and/or cognitive impairment, and up to 80% experience at least mild hearing loss. There is a heightened need for suitable and validated screening measures for the identification of hearing loss in persons with dementia that can be used across LTC settings. In this scoping review, we identified measures and approaches that have been used to evaluate the hearing abilities of older adults with dementia and cognitive impairment.

Design: This study followed a stepwise scoping review methodology, to identify all studies in the research literature reporting on the measurement of hearing in participants or clinical groups aged 65 years or older with a diagnosis of dementia or cognitive impairment. The electronic databases of Embase, Medline, PsycINFO, CENTRAL, and CINAHL were searched on January 13th 2020, using formulated search strategies to identify all relevant research reports published since January 1995.

Results: Of the 2,333 publications found in the database search, 193 scientific papers were included in the final review that described research in older adults with dementia and/or cognitive impairment, and contained potential tests that could be used to screen for hearing loss in this population. Data extracted from these studies revealed that pure-tone audiometry was the most frequently used measure of hearing in older adults with dementia, as cited in more than a third of the research. A wide range of other measures were also reported, with self- or other-reports and questionnaires, tympanometry, otoscopy, review of medical records, and the whisper test among the most frequently cited. Notably, 38% of the studies conducted hearing testing in a clinical or specialist setting, 10% of studies were conducted in laboratories and research settings, and 23% of the studies in LTC settings.

Conclusions: Although audiometry was found to be the most frequently administered test in older adults with dementia or cognitive impairment, it was also more frequently reported to require adaptations for use, exclusion

of participants who could not complete the test, or specific training or qualifications for those implementing and/or interpreting the test. Self-report measures, questionnaires, and the standard interRAI and Minimum Data Set assessments were most frequently used in LTC and residential care settings. The whispered voice test was used across a range of settings and was found to require fewer adaptations or specialist training for its administration. Given the current pandemic and increased risk of isolation to residents in LTC, the development of practice and policy recommendations for hearing screening in people living with dementia will likely need to be re-framed depending on factors such the testing context and the scope of practice of nursing professionals in this setting.

Poster #: 13

Exploring the Relationship Between Sound Acceptability, Emotional Reactivity, and Personality
Rachel J. Huber, AuD; Jani Johnson, AuD, PhD, University of Memphis, Memphis, MS

Objectives: Standard audiological evaluations help determine if a person is a candidate for amplification; however, they do not determine how a person will acclimatize and accept amplified sound. Hearing-aid wearers often report aversiveness to amplified sound, though, not always related to the loudness. Sound acceptability aims to encompass a holistic view of sound acceptance, including annoyance, aversiveness, and pleasantness, among other factors. Sound acceptability measurements may allow us to understand how an individual will react to amplified sound. There are several measurable traits in the literature that may relate to sound acceptability, such as personality traits. Neuroticism and Openness traits have been found to aid in prediction of hearing aid preference and are related to amplification outcomes. However, the relationship between emotional reactivity and sound acceptability has not been studied. It is not currently clear how individual characteristics like personality and emotional reactivity are related and how they may impact sound acceptability, especially for hearing aid users. The current research study aims to evaluate relationships between emotional reactivity, measures of personality, and sound acceptability in normal-hearing young-adults. It also aims to determine if emotional reactivity improves the ability to predict sound acceptability ratings. This research will provide insight into the driving factors that predict hearing aid acceptability.

Design: 53 normal-hearing young-adults participated in this exploratory survey study (M age=22.36 years; 39 female). Participants were recruited via email with a link to the survey including demographics, the International Mini-Markers personality test, the PERTH Emotional Reactivity Scale, and a listening task based on the Sound Acceptability Test. Participants were asked to complete these questionnaires and the listening task.

Results: The researchers found through regression analysis that neuroticism traits (r2=.64, p<.001) and agreeableness traits (r2=-.31, p=.02) are related to general negative emotional reactivity, while agreeableness (r2=.58, p<.001) and extraversion traits (r2=.31, p=.02) are related to general positive emotional reactivity. Of the traits tested, agreeableness and general negative emotional reactivity were most related to sound acceptability outcomes. When agreeableness traits and general negative emotional reactivity were used in a hierarchical regression predictive model, they were able to account for a small, but significant amount of variance in sound acceptability ratings for loud, transient sounds (r2=.14, p=.02); average episodic sounds (r2=.14, p=.02); loud episodic sounds (r2=.09, p=.09); and loud, continuous sounds (r2=.10, p=.07).

Conclusions: Emotional reactivity and personality are related, and together can account for a small amount of variance in sound acceptability ratings. Applied to populations with hearing loss, this may impact amplification fitting strategies and counseling of clinical patients. Further research in this area with other populations is

needed to determine the extent that sound acceptability in combination with personality traits and emotional reactivity will aid in predicting hearing aid outcomes.

Poster #: 14

Cognition Moderates Audiometric and Speech-in-noise Threshold Associations in Older Adults

April Emily Pereira, MA, University of Waterloo, Waterloo, Canada
Huiwen Goy, PhD; Kathleen Pichora-Fuller, AuD, PhD, University of Toronto Mississauga, Mississauga, Canada
Christian Giguère, PhD, University of Ottawa, Ottawa, Canada

Objectives: The Canadian Digit Triplet Test (CDTT) has been validated in younger adults with normal audiograms. The goals of the presented study were to validate the CDTT in older adults with normal audiograms and to examine CDTT results for older adults with varying audiometric status to determine if the association between CDTT speech-in-noise reception thresholds (SRTs) and audiometric pure-tone average (PTA) thresholds is influenced by non-audiometric factors.

Design: In Experiment 1, 16 participants (mean age = 70.1, SD = 5.7, range = 63-82 years) with normal pure-tone audiometric thresholds (,â§ 25 dB HL at frequencies below 4 kHz) were recruited from a volunteer pool. The CDTT (English-Male version) was presented to all participants following the validation procedures used previously to validate the CDTT in younger adults. Participants completed four versions (lists) of the adaptive CDTT. In addition, they were tested in four fixed-SNR conditions (-15, -13, -11, and -9 dB) with the noise level held at 65 dBA and the speech level varied. Validation results for the older adults were compared to those obtained previously for younger adults. In Experiment 2, 261 participants (67% female; (mean age = 71.2, SD = 6.1, range = 54-86 years) were recruited from volunteer pools. Based on the PTA of thresholds at 500, 1000, 2000, and 4000 Hz in the better ear, 132 had normal hearing, 103 mild hearing loss, and 26 moderate hearing loss. Based on neuropsychological tests, including the Montreal Cognitive Assessment (MoCA), 158 participants were considered to have normal cognition and 103 to have probable mild cognitive impairment (MCI). The CDTT (English-Male version) was presented adaptively. Analyses were conducted to evaluate the influence of PTA and cognition on the CDTT SRTs.

Results: In Experiment 1, the CDTT SRTs for 50% correct triplet recognition based on the psychometric functions for the fixed-levels SNR testing were about .5 dB worse for the older group than younger adults. Similarly, a small but significant difference (0.54 dB) favouring the younger group was found for the adaptive SRT results. In Experiment 2, there was an unsurprising strong association between SRT and PTA ($r = 0.76$). Beyond the contribution of PTA, SRTs were moderately associated with 8kHz thresholds ($r = 0.5$) and weakly associated with age ($r = 0.3$) and visual acuity ($r = 0.16$). However, there was a moderating effect ($p = 0.015$) of MoCA score on the relationship between SRT and PTA for those with hearing loss. Specifically, those with hearing loss and poorer MoCA scores had worse SRTs than would be predicted solely based on their PTA.

Conclusions: The CDTT validation for older listeners showed about a .5 dB worse average performance for older adults than for younger adults with normal audiograms. For older adults, the CDTT SRT is largely explained by their PTAs. Importantly, for those with hearing loss, poorer cognition worsens the SRT beyond what would be predicted based on the PTA. The use of digit triplet testing in those with cognitive impairment may need to be interpreted differently.

Poster #: 15

Mentored Student Poster Award

Comparison Between Remote and Laboratory Digits-in-Noise (DIN) Testing
Lina Motlagh Zadeh, AuD, PhD; Veronica Brennan, BS, Cincinnati Children's Hospital, Cincinnati, OH
De Wet Swanepoel, AuD, PhD, University of Pretoria, South Africa
David Moore, PhD, Cincinnati Children's Hospital, Cincinnati, OH

Objectives: The COVID-19 pandemic has highlighted the need for remote, but valid and reliable hearing tests. Previous studies have performed testing remotely but, to our knowledge, have not directly compared results in the same listeners with standard, rigorous lab or clinic testing. DIN is an objective, fast, and reliable speech-in-noise test that is widely used (e.g. WHO, 23andMe, AAA) and can be self-administered, remotely via internet or smartphone app. This study investigated the validity and reliability of the DIN test, self-administered by adults with impaired or normal hearing, with or without previous experience of the test.

Design: Speech reception thresholds (SRTs) of 47 self-reported normal hearing (NH, n=27) and hearing impaired (HI, n=20) adults (18-64 y/o) were measured at home (H-DIN), based on published procedures (Motlagh-Zadeh et al, Ear Hear, 2020). Consented listeners accessed a research hearDigits® website, used their own ear buds or headphones in a quiet place, and submitted results to a protected website. Thirty four (16NH/18HI) of the same listeners completed lab (L-DIN) testing (sound booth, Sennheiser headphones, same website) and pure-tone audiometry (0.25-8 kHz). All DIN testing used US-English digits 0-9, binaurally presented (in- or anti-phase) in different speech-shaped noise maskers (broadband, low-pass filtered at 2, 4, 8 kHz). An e-version of the short speech, spatial, and qualities of hearing questionnaire (SSQ-12) was completed.

Results: H-DIN correlated significantly with L-DIN in each test condition across all listeners. Mean H-DIN SRTs did not differ significantly from mean L-DIN SRTs in any test condition except for the in-phase broadband noise condition ($p=0.03$). Test-retest reliability was measured for in-phase broadband H-DIN in all listeners. High and significant intraclass correlation coefficients ($ICC=0.80$, $p<0.0001$) indicated high levels of internal consistency and reliability of the H-DIN. H-DIN SRTs correlated significantly with SSQ scores. Surprisingly, better-ear pure-tone average (PTA) correlated with H-DIN and SSQ in both NH and HI groups. As expected, NH listeners had significantly higher SSQ scores, and H-DIN and L-DIN SRTs than HI listeners.

Conclusions: Most listeners performed comparably on the H-DIN and L-DIN, but outliers were found among HI listeners in both test environments. SSQ scores were found to be good predictors of H-DIN in both NH and HI listeners, demonstrating the utility of the SSQ in a real-world environment. Overall, the results demonstrate high validity and reliability of remote DIN as a hearing screen. We found remote versions of the DIN have potential as primary hearing assessment tools, accessible to a large global audience.

Poster #: 16

Mentored Student Poster Award

Distortion-Product Otoacoustic Emission Signal-to-Noise Ratio Repeatability in Children and Adults
Nicholas Portugal, BA, San Diego State University, University of California San Diego, San Diego, CA
Gayla L. Poling, PhD, Mayo Clinic Rochester, Rochester, MN
Laura Dreisbach Hawe, PhD, San Diego State University, San Diego, CA

Objectives: Distortion-product otoacoustic emission (DPOAE) levels are repeatable over time in healthy, normal-hearing individuals making DPOAE levels an ideal metric for monitoring cochlear status in clinic and research applications. However, if DPOAE signal-to-noise ratio (SNR) values not levels are used for interpretation, the repeatability of this value needs to be established. This retrospective, cross-sectional study sought to determine DPOAE SNR repeatability in normal-hearing younger children (YC), older children (OC), young adults (YA), and a patient population.

Design: DPOAE data elicited at f2 frequencies of 1-16 kHz (f2/f1=1.2; L1/L2=65/50 dB SPL) were examined from 3-6 (YC, n=39) and 10-12 (OC, n=41) year old children. Data from 25 YA (14 female) collected at f2 frequencies of 2-16 kHz (f2/f1=1.2; L1/L2=60/50 dB SPL) were evaluated. DPOAEs elicited at f2 frequencies between 8-16 kHz (f2/f1=1.2; L1/L2=65/50 dB SPL) in 40 cystic fibrosis (CF) patients (17 females) comprised the final group for examination. Traditional calibration methods were used for the YA group while a depth-compensated in-ear calibration procedure was utilized for the other groups. OC and YA participants had normal behavioral thresholds and all participants had normal middle ear function. The CF participants had DPOAEs for at least 2 of the frequencies tested (8-16 kHz). Each participant attended four separate sessions.

Results: To examine the extent of variability to be expected for DPOAE SNR, absolute differences-between-trials (6 calculations) for each of the frequencies tested were determined for those with present DPOAEs. Greater variability was found in SNR compared to variability of DPOAE levels (Ldp) for all populations. The average DPOAE SNR differences-between-trials for the higher (8-16 kHz) and lower (2-8 kHz) frequencies for YC were 7.33 (Ldp 4.55 dB) and 7.94 dB (Ldp 3.38 dB), respectively. OC differences for high and low frequencies were 7.12 (Ldp 4.44 dB) and 7.43 dB (Ldp 2.97 dB), respectively. YA differences for high and low frequencies were 6.52 (Ldp 5.48 dB) and 4.57 dB (Ldp 3.15 dB), respectively. SNR differences at higher frequencies for the CF group were 6.09 dB (Ldp 1.96 dB). Average SNR differences-between-trials were greater for lower frequencies than higher frequencies with depth-compensated calibrations. Correlations and confidence intervals between trials were calculated and will be discussed. SNR values across the frequencies tested in YC, OC, and YA resulted in a band-pass function with the greatest values occurring at approximately 4-6 kHz. There is a subsequent peak in the average DPOAE levels and a valley in the average noise floors which appear to be driving the SNR band-pass function.

Conclusions: Average SNR differences-between-trials across all frequencies are greater than those for average DPOAE levels. Improved calibration methods result in SNR differences-between-trials that are similar across all frequencies, highlighting the importance of stimulus level control at frequencies subject to the effects of standing waves. Evidence supports that SNR values play a role in determining and monitoring DPOAE levels in the presence of varied testing conditions and populations. However, when monitoring cochlear health, DPOAE levels show less variability across trials than SNR values.

Poster #: 17

Mentored Student Poster Award

Amikacin Ototoxicity: Risk Factors and Sensitivity of Grading Scales

Cecilia Mercedes Lacey, BA, University of Pittsburgh, Bethel Park, PA
Carmen Brewer, PhD; Jen Chisholm, AuD; Chris Zalewski, PhD; Julie Christensen, MS; Talah Wafa, AuD, PhD; H. Jeffrey Kim, MD, National Institute on Deafness and Other Communication Disorders, Bethesda, MD
Kevin Fennelly, MD, National Heart, Lung, and Blood Institute, Bethesda, MD

Andrea Beri, NIH Clinical Center, Besthesda, MD
Kenneth Olivier, MD, National Heart, Lung, and Blood Institute, Bethesda, MD

Objectives: Amikacin is an ototoxic aminoglycoside antibiotic essential in the treatment ofsome mycobacterial infections. Permanent sensorineural hearing loss isusually seen in the high frequencies first and then extends to the lower frequencies withprolonged amikacin exposure. The reported prevalence of amikacin ototoxicity is highly variable. Factors suspected to contribute to this high variability include patient variablessuch as sex, previous amikacin exposure, and pre-existing hearing loss, as well as routeof drug delivery (IV versus inhaled), and the operational definition of the ototoxicchange. The objective of this study is to compare the prevalence of ototoxicity in a largecohort of patients receiving amikacin through the ASHA, TUNE, and CTCAE grading scaleswith regard to sex, route of administration, previous amikacin exposure, and pre-existinghearing loss.

Design: We conducted a retrospective review of medical records for 318 patients withorders for amikacin between April 1987 and January 2019. A total of 167 (104 females)aged 5-85 years met inclusion criteria (treatment with IV or inhaled amikacin, baselineaudiogram, and at least one post-treatment audiogram). Pure tone thresholds, amikacintreatment history, and patient demographics were extracted for analysis. Pure tone airconduction thresholds were the primary outcome measure except in patients withconductive or mixed hearing loss, in which case bone conduction thresholds were used. Pre-existing hearing loss was defined as a pure tone average >20 dBHL at baselineaveraged across.5, 1, 2, 4 kHz or 4, 6, 8 kHz. Data were analyzed according to theASHA definition of ototoxicity which included standard (0.25-8 kHz) and ultra-highfrequency (9-20 kHz) thresholds. Additionally, ototoxic changes were classifiedaccording to the modified TUNE (1-12.5 kHz) and CTCAE (0.25- 8 kHz) ototoxicity scales.

Results: ASHA ototoxicity criteria detected a significantly higher prevalence of ototoxicity (60%for standard frequencies and 74% when ultra-high frequencies were included) than theTUNE (41%) or CTCAE (47%) scales. There was a significant difference in the amount ofthreshold decline at 8, 10, and 12.5 kHz for those treated with IV versus inhaledamikacin; this difference was captured by the CTCAE only. Similarly, there was asignificant difference in threshold shift for those with pre-existing hearing loss at 12.5and 14 kHz; this was not captured by any of the ototoxicity scales. We observed nosignificant difference in the amount of threshold shift or ototoxicity classification forprevious treatment with amikacin or patient sex.

Conclusions: Prevalence of amikacin ototoxicity ranged from 41%-74% and was dependent on thedefinition of hearing change and grading scale. ASHA criteria were the most sensitive,and the sensitivity increased when thresholds for the ultra-high frequencies wereconsidered. There was no significant effect of sex or previous treatment with amikacin. Route of drug administration significantly affects the amount of ototoxicity observed inthose treated with IV versus inhaled amikacin.

Poster #: 18

Mentored Student Poster Award

Association between Cystic Fibrosis-Related Diabetes and Self-Reported Ototoxicity Symptoms
Nicole Marie Nichols, BA, Oregon Health & Science University, Portland, OR
Jay Vachhani, AuD, VA Portland Healthcare System - National Center for Rehabilitative Auditory Research, Portland, OR
Ma. Vida Echaluse; Angela Garinis, PhD, Oregon Health & Science University, Portland, OR

Objectives: This investigation examined the relationship between self-reported ototoxicity symptoms and cystic fibrosis-related diabetes (CFRD) in patients with CF treated with aminoglycoside antibiotics. People without CF that have either type 1 or type 2 diabetes are shown to have a higher prevalence of hearing loss due to changes in the vascular structures of the neural system, oxidative stress and due to mitochondrial damage to the auditory system. CFRD is the most common comorbidity in patients with CF and shares characteristics of both type 1 and type 2 diabetes. Hypothesis:Patients with CFRD will have a higher prevalence and severity of ototoxicity-related symptoms (tinnitus and/or balance problems) as compared to patients with CF who do not have CFRD.

Design: Participants with CF were recruited from the CF centers at Oregon Health & Science University for this investigation. Patients completed a series of questionnaires to determine their experience with ototoxicity-related symptoms. Questionnaires included the Tinnitus Screener, Tinnitus Functional Index (TFI), Tinnitus Ototoxicity Monitoring Inventory (TOMI) and the Activities-Specific Balance Confidence (ABC) Scale. Medical chart review was conducted to determine if patients had a diagnosis of CFRD determined by insulin treatments and HbA1C levels. Intravenous (IV) aminoglycoside treatment history was also determined for each patient.

Results: Patients with CF were classified into groups with or without tinnitus and/or balance concerns; and with or without CFRD based on insulin and average/max HbA1C levels. Preliminary data was collected from 17 patients with CF [8 F: 9 M; Mean age= 30 years; Age range =19-48 years]. Of these patients, 9 did not have CFRD and 8 had a diagnosis of CFRD (4 with insulin treatment and 4 without insulin treatment). Preliminary data suggests that individuals with CFRD report more severe problems of tinnitus and balance problems based on self-reported symptoms, than either individuals with CFRD who do not receive insulin or individuals without CFRD. Participants without CFRD largely do not report any tinnitus and indicate high confidence in their balance.

Conclusions: Patients with CFRD who receive insulin are exhibiting a higher prevalence of self-reported ototoxic symptoms, then patients without CFRD. To help maintain quality of life in these individuals, ototoxicity monitoring and management is recommended to closely monitor patients with CFRD who may be at higher risk for ototoxicity-related symptoms.

Poster #: 19

Radiology Update for Audiology Professionals: Improving Access for Patients in Otolaryngology
Razan Al-Fakir, MD; Sridhar Krishnamurti, PhD, Auburn University, Auburn, AL

Objectives: The gap between audiology and otolaryngology continues to widen despite a common concern on the part of both professionals on diagnosis and intervention of hearing loss and balance disorders. Site-of-lesion testing continues to be a focus in otolaryngology practices. Clinical testing by audiologists is often combined with radiologic procedures ordered by the otolaryngologist. Training in otolaryngology today on site-of-lesion testing, however, seems to weigh more heavily on radiology than clinical/bedside audiology testing due to the plethora of radiological tools available and emphasis on reducing litigation. In audiology training programs, training seems to be restricted to medical disorders of the auditory and balance system with little attention towards the information gathered from radiology measures. Audiologists and Otolaryngologists often provide combined expertise on patients with a variety of otologic and neurotologic disorders, including Acoustic Neuroma, Meniere's disease, Temporal bone fractures, Idiopathic Sudden Sensorineural Hearing Loss, Vertigo, and Semicircular Canal Dehiscence. Yet, the fundamental lack of awareness on audiologist's part on advances in radiology and a similar lack of awareness of latest audiology tools on the otolaryngologist part makes the

cohesion between these professionals less than ideal at this time. To add to this problem, there exists a paucity of literature to describe a change of emphasis towards audiology-led referral patterns in the healthcare system in the United States. Enabling an exclusively audiology-led approach is further emphasized by the International Classification of Functioning, Disability, and Health Core Sets for Hearing Loss, which is intended to maximize treatment outcomes in individuals with auditory and balance disorders. The aim of presentation is to inform audiologists to assist in referrals of patients with patients in otolaryngology by combining audiologic expertise with radiologic screening measures.

Design: An algorithm to look at applications of X-ray and CT scan technologies for patients with temporal bone fractures and superior semicircular canal dehiscence will begin the presentation. This will be followed by applications of MRI to identify space occupying lesions of cerebellopontine angle. Radiologic imagining such as magnetic resonance imaging (MRI) is the established gold-standard screening tool to investigate causes of asymmetrical hearing loss, which is primarily detected by audiologic evaluation even before the audiology department receiving direct access referrals operates alongside the Otolaryngologist services. Currently, there is a significant gap of guidelines on MRI referral by audiologists via the Otolaryngologist. Lack of radiologic imaging education in Au.D programs and researches showing the value of direct audiology access for radiologic imaging are the major factors. The presentation will end with a discussion of functional MRI (fMRI) applications in audiology. The recent advancement of functional magnetic resonance imaging (fMRI) allows for high spatial resolution anatomic imaging with the hemodynamic specificity. Functional MRI (fMRI), has become a novel and widely used neuroimaging technique to explore the pathophysiology of neurologically-based disorders. fMRI is sensitive to low frequency (0.01-0.1 Hz) spontaneous fluctuations in the blood oxygenation level dependent (BOLD) signal and offers high spatial and temporal resolution despite the noise generated by scanners making auditory testing difficult.

Results: A radiologic algorithm approach combined with audiological test battery will be used the bridge the relationship between these measures used in otolaryngology.

Conclusions: Radiologic algorithms combined with auditory test measures will be demonstrated to improve efficacy in service delivery and education offered by audiology professionals.

Poster #: 20

Rater Reliability in Different Listening Conditions

Brett Welch, MS; Michael Peagler, BS; Christopher Brown, PhD; Leah Helou, PhD, University of Pittsburgh, Pittsburgh, PA

Objectives: Preliminary evidence shows that when listeners make immediate judgments about a speaker's personality based on their speech, listeners are not very accurate. However, despite the low accuracy, listeners demonstrate large levels of agreement (i.e., high interrater reliability). While listeners largely agree about how a person sounds, it remains to be seen how reliably a listener comes to the same conclusion about the same speaker over multiple trials (i.e., intrarater reliability). Furthermore, to our knowledge, no evidence exists that interrogates the degree to which the audio signal quality affects these ratings. Thus, the present study seeks to investigate inter- and intrarater reliability of personality judgments based on speech samples. Additionally, we seek to understand if and how the signal quality affects listener inter- and intrarater reliability.

Design: Utilizing a prospective quasi-experimental design, we will recruit up to 30 listeners to provide demographic and personality judgments of pre-recorded speech samples. 20 speech samples (balanced for sex)

will serve as the stimuli. To examine the effects of signal quality on listeners' reliability, we artificially degraded each of the 20 speech samples. Each sample will have ten versions - i.e., a non-altered version, and nine versions that range from mild to severe degradation (reduced signal-to-noise ratio). These 200 speech samples will be played in random order to the listeners. Listeners will rate demographic features (e.g., perceived age) and personality traits derived from a validated personality inventory, the Big Five Aspect Scales.

Results: We are currently collecting data for this study. We aim to have completed data collection for all 30 subjects by March 2021. We will calculate interclass correlation and Cohen's kappa (and/or Krippendorff's alpha) to assess interrater and intrarater reliability. We will also use a mixed effects model to estimates the effects of the audio degradation and whether the order the listeners heard the sample impacts their reliability.

Conclusions: To our knowledge, this study is the first to examine the effects of less-than-optional listening conditions on listener judgments of a speaker's demographic features and personality. This study will also provide evidence for inter- and intrarater reliability of listeners' judgments of speakers. It remains to be seen if some people are more or less reliable than others when making these judgments based on speech alone. These results will inform future investigations in our programmatic line of research that seeks to understand how speakers encode personality information via the speech signal.

AUDITORY PROCESSING

Poster #: 21

Peripheral and Central Auditory Function in Klinefelter Syndrome

Celia Zhang, AuD, University at Buffalo, The State University of New York, Buffalo, NY
Julie Christensen, MS; Kelly King, AuD, PhD; Jennifer Chisholm, AuD; Christopher Zalewski, PhD; Carmen Brewer, PhD, Audiology Unit, Otolaryngology Branch, National Institute on Deafness and Other Communication Disorders, National Institutes of Health, Bethesda, MD

Objectives: Klinefelter syndrome (KS) is the most common congenital sex chromosome aneuploidy in males. Medical manifestations of KS include androgen deficiency, hypogonadism, and infertility. The extra X chromosome in the 47, XXY karyotype can also lead to a range of cognitive and language deficits. While subtle anomalies of auditory processing dysfunction have been reported in individuals with KS, including difficulty understanding speech in background noise, the comprehensive auditory phenotype remains unknown. The purpose of this study is to further elucidate the peripheral and central auditory manifestations in individuals with KS.

Design: We evaluated 31 males with KS, aged 19-57 years (M=34.2 years, SD=10.1). Detailed otologic and audiologic histories were extracted from the medical record. Comprehensive audiologic assessments consisted of pure-tone and speech audiometry, immittance audiometry, neurodiagnostic auditory brainstem response (ABR), and auditory processing (AP) evaluations. Per ASHA guidelines, reduced scores on two or more auditory processing tests were classified as consistent with an auditory processing disorder (APD).

Results: Sixteen of 31 participants (51.6%) reported a history of ear infections. Twenty (64.5%) reported a history of noise exposure. Bilateral tinnitus was reported in five (16.1%) of which four also had a history of noise exposure. Eighteen (58%) described difficulty understanding speech in background noise. Thirteen (41.9%) described some form of dizziness/vertigo. Four (12.9%) reported previous head injury/loss of consciousness, three (9.7%) presented with a diagnosis of ADHD, and three (9.7%) had a previous diagnosis of

APD. Clinically defined peripheral hearing loss using the four-frequency pure-tone average (.5, 1, 2 and 4 kHz; 4F-PTA) was limited to eight of 62 ears (12.9%) or five of 31 participants (16.1%). When hearing sensitivity was compared to age- and sex-based norms, the 4F-PTA and/or HF-PTA (6 and 8 kHz) were outside the 95th percentile for all five participants. QuickSIN was performed on 22 participants; four (18.2%) had scores suggesting mild difficulties understanding speech in noise, three of whom had peripheral hearing loss. Neurodiagnostic ABR was conducted on 30 participants and was within normal limits in 25 (83%). Abnormal ABR findings included poor waveform morphology (n=1), prolonged interpeak latencies (n=2), abnormal interaural wave V (n=1) and prolonged absolute and interpeak latencies (n=1). A total of 15 of 31 (48.4%) participants met ASHA criteria for an APD, two of whom had a previous diagnosis of APD. Most abnormalities were found on tests of temporal processing (gaps-in-noise, 41.4%), pitch-pattern recognition (31%) and dichotic listening (double dichotic digits, 24.1%).

Conclusions: These data suggest that peripheral hearing deficits are uncommon in KS. The high prevalence of noise exposure in our cohort may be a confounding factor contributing to elevated pure-tone thresholds. Moreover, in agreement with previous reports of difficulty hearing in background noise, individuals with KS are likely to have an APD. As a caveat, comorbid conditions, including speech and language deficits and the presence of ADHD require the APD results to be interpreted with caution. Further research in the realm of neuropsychology may be warranted to reveal the mechanisms underlying the auditory processing phenotype in this population.

Poster #: 22

Identifying Patterns of Auditory Difficulties in Individuals with Brain Injury

Tess K. Koerner, AuD, PhD; Melissa Papesh, AuD, PhD, VA RR&D NCRAR, Portland, OR
Frederick Gallun, PhD, Oregon Health and Science University, Portland, OR

Objectives: Normal-hearing individuals with a history of brain injury resulting from blast- and/or non-blast-related causes often report difficulties understanding speech in background noise. Previous work has shown that these different causes of traumatic brain injury (TBI) can result in measurable auditory processing deficits as well as higher self-reported hearing difficulties compared to control participants without a history of brain injury. However, a systematic comparison of individuals with blast-related injury, non-blast-related TBI, and control individuals with no history of brain injury on a comprehensive battery of speech understanding, auditory processing, and cognitive measures has yet to be established. This work used Principal Component Analysis (PCA) to identify patterns in subjective complaints and performance across Veterans with and without brain injury and to identify factors that are most sensitive to differences in auditory difficulties across participant groups.

Design: Data from a total of 44 normal-hearing Veterans with a history of blast exposure, 18 normal-hearing Veterans with a history of non-blast TBI, and 33 normal-hearing control participants with no history of blast exposure or non-blast TBI were used in the current analysis. Measures that were subjected to a PCA were drawn from tests of central auditory processing (e.g., Dichotic Digits Test, Staggered Spondaic Words Test, Frequency Pattern Test, and SCAN subtests), speech understanding (e.g., Words in Noise Test, the QuickSIN, and the Compressed Speech Test), cognitive performance (e.g., Brief Test of Attention and the Reading Speed test), as well as self-report questionnaires (e.g., the Speech, Spatial, and Qualities Hearing Scale, the Hearing Handicap Inventory for Adults, and the Tinnitus Handicap Inventory).

Results: Results from the PCA provided information about factors that may be useful for differentiating between participant groups. This analysis also allowed for the identification of specific measures that highly influenced each component as well as allowed for an examination of relationships among each test measure.

Conclusions: These results provide novel information regarding patterns of auditory difficulties across participants with a history of brain injury stemming from blast exposure or non-blast related causes compared to control participants with no history of brain injury. In addition, the identification of measures that highly influence factors that are important for differentiating between participant groups will allow for the development of more efficient and targeted test batteries for the assessment and treatment of normal-hearing individuals with auditory difficulties resulting from brain injury.

Poster #: 23

Aging Effects on a Concurrent and Sequential Dual-Task Paradigm
Kimberly Skinner, AuD, PhD, A.T. Still University, Mesa, AZ

Objectives: Difficulty with speech communication in noise is a common problem among elderly individuals. Older adults often report challenges with understanding speech, particularly in noisy environments. Growing evidence suggests that cognitive effort is a significant factor in speech understanding in noise. Although hearing loss is commonly experienced by older adults, older adults also experience decline in a number of cognitive abilities. The primary focus of this study was to measure cognitive effort (listening effort) in young and older adults with normal hearing while completing a speech in noise task. This study also examined some methodological issues for the measurement of listening effort. The most common means of behavioral assessment of listening effort is through use of a dual-task paradigm (DTP), whereby participants perform a "primary" speech-perception task along with a "secondary" task that does not involve speech perception. A reduction in performance on the secondary task can be viewed as a measure of listening effort. The two tasks can be administered concurrently or sequentially. It is not known whether DTPs administered sequentially and concurrently in the same person will yield similar results. It was hypothesized that if the amount of listening effort measured was significantly different between the concurrent and sequential tasks then this would support a hypothesis that different cognitive processes are being evaluated in each dual-task paradigm.

Design: A total of 35 individuals participated the study, 17 young normally-hearing listeners (mean age 20.9 years, sd = 4.7 years) and 18 older normally-hearing listeners (mean age 60.4 years, sd = 4.7 years). Inclusion criteria included hearing thresholds within normal limits from 250-4,000 Hz and a passing score ($\geq$ 26) on the Mini Mental State Exam.The primary task in the DTP was a speech-identification task with a target talker and two competing talkers. The secondary task was either concurrent or sequential recall of a portion of the target message. The task was performed at each participant's individual performance level whereby 80% accuracy on each component of the DTP was achieved.

Results: The primary finding was that, when the performance of young and older adults was equated at baseline, few effects of age on listening effort were seen. Differences between the concurrent and sequential conditions emerged, however, including a larger dual-task effect on the secondary task, slower response times, and poorer performance overall for the sequential condition.

Conclusions: It was hypothesized that if the amount of listening effort measured was significantly different between the concurrent and sequential tasks then this would support a hypothesis that different cognitive processes are being evaluated in each dual-task paradigm. Though the concurrent and the sequential DTP

clearly yielded different results, it is not likely that this indicates that completely different cognitive processes are being evaluated in each DTP. Moderate correlations, at least in the older group, were seen between the dual-task effects for the speech segregation and the recall tasks. This suggests that the sequential DTP was a more difficult task overall.

Poster #: 24

The Effects of Music Experience on Hearing Ability in Young Adults

Fawen Zhang, MD, PhD, University of Cincinnati, Cincinnati, OH
Elizabeth Urban, University of Cincinnati, Villa Hills, KY
Aubrey Stoll, University of Cincinnati, Cincinnati, OH
Madeline Skeeters, University of Cincinnati, LaGrange, KY

Objectives: Hearing loss negatively affects listeners' ability to detect frequency changes of sounds, which is important for speech perception performance. Music training in musicians has been proven effective in improving frequency change detection, and possibly speech perception. Previous studies have examined short-term music training on normal and abnormal hearing. Training approaches varied including music playing and music active listening. However, music training/exposure may cause compromised hearing sensitivity, which will affect hearing functions in pitch perception and speech in noise. The goal of this study is to examine music background/experience assessed with surveys and the ability of hearing assessed with online tests in individuals who consider themselves as normal hearing listeners. The results will inform the public of the effects of music experience (music listening and training experience) on human hearing.

Design: Participants will include young adults (20-30 years) who do not have known previous hearing disorders or hearing loss. A questionnaire consisting of questions in four different categories (music training background, music listening experience, noise exposure background, and subjective evaluation of hearing ability in daily life) will be administered via Redcap (Research Electronic Data Capture) platform. Hearing ability will be tested using the Digit-in-Noise online test and the data will be entered in Redcap by the participants. Participation in this study is voluntary. The number of subjects which will be included in this study is an ongoing count.

Results: Data collection and analysis is ongoing. It is expected that the variability in the performance of Digit-in-noise test and subjective evaluation of hearing ability is accounted for by the variability in music training background, music experience, and noise exposure.

Conclusions: Data analysis is ongoing. The results will inform the public of effects of music listening and training experience on human hearing therefore will have important impact on how to improve hearing abilities through auditory rehabilitation methods that incorporate music training/exposure.

Poster #: 25

Mentored Student Poster Award

Brain Resting State Functional Connectivity and Age-Related Hearing Loss

Alexandria Lauren Irace, BA, Department of Otolaryngology-Head and Neck Surgery, NewYork-Presbyterian Hospital/Columbia University Irving Medical Center, New York, NY

Brady Rippon, MS; Mouna Tahmi, MD, Department of Medicine, Vagelos College of Physicians and Surgeons, Columbia University Irving Medical Center, New York, NY
Jose Luchsinger, MD, Department of Medicine, Vagelos College of Physicians and Surgeons, Columbia University Irving Medical Center, New York, NY; Department of Epidemiology, Joseph P. Mailman School of Public Health, Columbia University Irving Medical Center, New York, NY
Justin Golub, MD, Department of Otolaryngology-Head and Neck Surgery, NewYork-Presbyterian Hospital/Columbia University Irving Medical Center, New York, NY

Objectives: The objective was to examine associations between intra-network functional connectivity measured using resting state functional magnetic resonance imaging (rsfMRI) and age-related hearing loss.

Design: This investigation was a cross-sectional analysis of an ongoing prospective cohort study. The analysis included a community-based cohort of 73 late middle-aged adults without dementia who underwent audiometry and rsfMRI from 2016-2020. Hearing thresholds were averaged to calculate the pure-tone average (PTA) for each ear. PTA in the better ear served as the measure of hearing. Functional connectivity was estimated as temporal correlations among a set of 53 putative functional regions defining nine networks that cover the brain's better known functional networks: auditory, cingulo-opercular, default mode, dorsal attention, frontoparietal control, salience, somatomotor, ventral attention, and visual network. The average inter-nodal correlation within each network provided an estimate of intra-network functional connectivity. Linear regression was performed to analyze the association between resting state functional connectivity and a 10 dB worsening in hearing. Models were adjusted for age, gender, years of education, and hearing aid use.

Results: Mean age was 64.6 (± 3.7) years. Mean PTA in the better ear was 21.2 (± 9.0) dB. Univariate regressions demonstrated that a 10 dB worsening in hearing was associated with higher intra-network connectivity within the frontoparietal control network (estimate=0.073, p=0.04). Adjusting for covariates, a 10 dB worsening in hearing was associated with lower intra-network connectivity within the visual network (estimate=-0.181, p=0.03). A near-significant relationship was also observed between hearing and higher frontoparietal control network connectivity in the adjusted model (estimate=0.072, p=0.08).

Conclusions: Age-related hearing loss may be associated with a less coherent visual network due to audiovisual cross-modal reorganization, in which visual processing maps onto cortical areas normally used for auditory processing. Conversely, hearing loss may be associated with a more coherent frontoparietal control network due to increased listening effort requiring increased top-down attentional control. These findings add to growing evidence that age-related hearing loss is associated with neuroplastic changes in the brain. Future research should confirm these results in a larger sample and longitudinally study how functional networks change as hearing loss progresses.

COCHLEAR IMPLANTS

Poster #: 26

Verbal Working Memory Error Profiles of Youth with Cochlear Implants

William G. Kronenberger, PhD; Daniel Romano, BS; Shirley Henning, MS; Caitlin Montgomery, MA; Allison Ditmars, BS; Courtney Johnson, BS; Hannah Bozell, BS; Adeline Yates; David Pisoni, PhD, Indiana University School of Medicine, Indianapolis, IN

Objectives: The objective of this study was to identify the types of memory errors that underlie delays in verbal short-term/working memory in youth with cochlear implants. We hypothesized that cochlear implant users would be more likely than normal-hearing peers to make phonological substitution errors (e.g., substituting 'M' for 'N' when recalling words from short-term verbal memory, reflecting underspecified phonological representations of words in short-term memory. Conversely, we expected that other types of errors (order errors, addition errors, and nonphonological substitution errors) would not differ between youth with cochlear implants and those with normal hearing.

Design: Participants were 28 pediatric long-term cochlear implant users (implanted at ≤ 3 years of age; > 7 years of cochlear implant use) aged 8-17 years and 25 normal-hearing peers who did not differ significantly in terms of age, income, gender, or nonverbal intelligence. Participants in both samples were recruited from cochlear implant programs, hospital settings, community organizations, schools, and community settings with the same ads. The Letter-Number Sequencing subtest of the Wechsler Intelligence Scale for Children, Fifth Edition was administered in standard spoken language format by two licensed speech-language pathologists as part of a larger battery of speech, language, and neurocognitive tests. The Letter-Number Sequencing subtest is a validated verbal working memory test that presents a random, mixed sequence of letters and numbers; subjects are then asked to recall and reorder the numbers in ascending order, followed by the letters in alphabetical order. In addition to obtaining accuracy scores for the number of correctly recalled sequences, errors were systematically coded as order errors, addition errors, omission errors, phonological and nonphonological substitution errors, and other errors. Accuracy and error scores were compared between the cochlear implant and normal-hearing samples. Correlation analyses were used to investigate associations between Letter-Number Sequencing scores and measures of speech, language, and memory within each sample.

Results: Youth with cochlear implants correctly recalled fewer total sequences, number sequences, and letter sequences than normal-hearing peers. Youth with cochlear implants made more phonological errors than normal-hearing subjects, but the samples did not differ on any other error measure. For both groups, the number of correct sequences correlated with performance on other tests of verbal working memory. However, the number of correct sequences was associated with speech perception and language abilities in the cochlear implant sample alone. Greater numbers of phonological errors were associated with poorer speech, language, and working memory skills in the sample of cochlear implant users alone.

Conclusions: Verbal working memory delays in youth with cochlear implants are due in part to fragile, underspecified phonological representations of words in memory, leading to phonological errors during recall. Greater numbers of phonological errors are associated with poorer spoken language and working memory outcomes in cochlear implant users, but not in normal-hearing peers.

Poster #: 27

Do Low Stimulation Rates Interfere with Place-Pitch

Hannah E. Staisloff, BS; Justin Aronoff, PhD, University of Illinois at Urbana-Champaign, Champaign, IL

Objectives: Temporal and place information both provide pitch cues for single channel cochlear implant (CI) stimulation. This raises the possibility that using low stimulation rates, which provide a temporal pitch cue, may degrade place-pitch judgments. If this is the case, participants should have more difficulty completing a place-pitch-matching task when using a low stimulation rate compared to when using a stimulation rate too high to provide a perceivable temporal pitch. To determine if that is the case, six bilateral CI users completed a pitch-matching task twice, once with a low stimulation rate and once with a high stimulation rate.

Design: Participants matched the pitches of single electrode stimulation in the left ear with that of single electrode stimulation in the right ear by moving the stimulation location in the right ear. Participants were tested with stimuli using one of two stimulation rates. The first stimulation rate was 976 Hz (no temporal pitch condition), a rate that previous research suggests is above the limit of temporal pitch for CI users. The second stimulation rate was 100 Hz (temporal pitch condition), a rate that falls within the range of temporal pitch for CI users. The same stimulation rate was always used in both ears. Participants were tested with five reference locations spread throughout the array and completed three pitch-matching trials per reference. The consistency of their pitch matches (i.e., the standard deviation of each participant's pitch matches) for a given reference electrode was compared across stimulation rates.

Results: The results indicated that the standard deviation of the pitch matches was similar for both stimulation rates. This was true regardless of the reference location.

Conclusions: The results suggest that the ability to compare place-pitches is not affected by using low stimulation rates.

Poster #: 28

Music Listening Habits and Experiences in Cochlear Implant Users

Ramon Bustos, BS; Charles Limb, MD, University of California, San Francisco, San Francisco, CA

Objectives: Cochlear implant (CI) users demonstrate limitations in music perception, therefore we designed a study to compare music listening habits in CI users and individuals with normal hearing (NH). The goal of this exploration of music listening habits was to improve our understanding of the impact CIs have on hearing restoration in an everyday, real-world context.

Design: We conducted a survey-based cross-sectional study to examine music listening habits in CI users and NH individuals. A Qualtrics survey was distributed August 2019-2020 and advertised via online support groups (Cochlear, MED-EL, Advanced Bionics, Facebook), SurveyCircle, and physical bulletin board postings. Eligible participants included children (>14 years) and adults; we excluded CI users that were activated within three months of the survey. Our primary outcome measures were differences in music listening habits between NH individuals and CI users. Responses were analyzed by two-tailed, unpaired t-test.

Results: A total of 44 CI users (43 adults, 1 child) and 71 NH individuals (all adults) participated in this study, totaling 115 responses. Of these, 37 (84.1%) CI users and 65 (95.8%) NH individuals listened to music. We found that CI users utilized their implant’s microphone (n=31, 49.2%), streamed wirelessly (n=20, 31.3%), and/or used direct-line audio input (n=12, 15.8%) for music listening. Less CI users (n=21, 53.8%) spent more than one hour per day listening to music compared to NH individuals (n=54, 83.1%). The top three music genres CI users listened to were Classical (n=26, 59.1%) Rock (n=25, 56.8%), and Oldies (n=24, 54.5%) while NH individuals preferred Pop (n=48, 70.6%), Rock (n=46, 67.6%), and Hip-hop (n=43, 63.2%). Similar proportions of CI users and NH individuals enjoyed listening for the beat, melody, or timbre of a musical piece (p=0.20, 0.46, 0.47, respectively). Of those three musical elements, CI users (n=14, 43.8%) rated melody as the most enjoying (p=0.18). Both groups further displayed similar proportions of individuals who enjoyed listening to music at home, through a hand-held device, in a vehicle, and at a live performance. However, CI users (n=21, 58.3%) reported that listening to ambient music in public locations was perceived as less enjoyable than listening in a quiet-focused environment compared to NH listeners (n=18, 27.3%) (p=0.002). Finally, few CI

users (n=5, 14.3%) demonstrated discomfort while listening at a live performance compared to NH individuals (n=40, 61.5%) ($p<0.0001$).

Conclusions: CI users demonstrate different genre preferences and spend less time listening to music compared to NH individuals. Interestingly, CI users demonstrate less auditory discomfort to live performance listening in comparison to NH listeners. These differences in music perception shed light on the limitations of CI-mediated listening, but also suggest that many CI users are regular participants in musical activities.

Poster #: 29

Using ECAP Data to Improve Cochlear Implant Programming

Kara C. Schvartz-Leyzac, AuD, PhD, Medical University of South Carolina, Charleston, SC
Teresa Zwolan, PhD; Bryan Pfingst, PhD, University of Michigan, Ann Arbor, MI

Objectives: In cochlear-implanted animals, the density of surviving spiral ganglion neurons (SGN) accounts for about 40-50% of the variance in peak amplitude and linear slope values of the electrically-evoked compound action potential (ECAP) amplitude-growth function (AGF). Moreover, the magnitude of change in these ECAP measures as a result of increasing the interphase gap (IPG) of the biphasic pulse (the "IPG Effect") also reflects SGN density in animals, and might be less influenced by non-neural factors. Furthermore, the IPG Effect has been found to predict speech recognition in humans. We hypothesized that ECAP IPG Effect measures in humans could be used to optimize electrode site selection in cochlear implant (CI) mapping, thereby improving speech recognition performance.

Design: Participants included 14 adult human subjects (18 ears total) with Cochlear™ devices. ECAP AGFs were collected using two interphase-gap conditions (7 and 30 μs IPG), and the IPG Effect was calculated for peak amplitude measures on each electrode. Two experimental maps were created. For the first map, the five electrodes with the largest (best) ECAP IPG Effect were deactivated. For the second map the five electrodes with the smallest (worst) ECAP IPG Effect were deactivated. The deactivation strategy maintained tonotopicity with respect to the subjects' everyday map. Performance on sentence recognition in noise and consonant recognition in quiet was assessed while subjects used the experimental maps and while they used their normal map, with all electrodes active. Testing was completed using a double-blinded design. Post-operative computerized tomography was also completed for 11 ears to examine factors that may contribute to the efficacy of an electrode site selection approach.

Results: Performance when listening to a map for which the electrode sites with the highest (best) ECAP IPG values were selected resulted in significantly better sentence recognition in noise (5.92 dB SNR at 50% accuracy) compared to performance when listening with a map in which the electrode sites with the lowest (worst) ECAP IPG values were selected (6.83 dB SNR). Results using the experimental map with the best ECAP IPG values were comparable to those obtained when subjects used their everyday map (6.02 dB SNR). Further analyses showed that neither medial-lateral distance (as assessed by post-operative CT scans) nor across site variation in the ECAP IPG Effect contributed to the efficacy of an electrode site-selection approach. A greater percentage of electrodes located within the scala tympani within an ear resulted in a more advantageous SNR when using the highest ECAP IPG map compared to the lowest ECAP IPG map. Consonant information transmission analysis showed better performance for place cues when listening with the highest compared to the lowest ECAP IPG map.

Conclusions: Results suggest that ECAP measures, which estimat underlying features of neural health, are important for sentence recognition performance in noise, and that ECAP data can be used to alter programming maps to either improve or worsen performance in adult CI recipients. Analysis suggests that scalar location might influence the efficacy of an electrode site selection approach.

Poster #: 30

Insertion Depth and Vocal Pitch Differences for Cochlear Implant Users

Simin Soleimanifar, PhD; Hannah Staisloff, PhD; Justin Aronoff, PhD, Department of Speech and Hearing Science, College of Applied Health Science, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL

Objectives: Adults with bilateral cochlear implants (CIs) produce different vocal pitches (F0) when producing sustained vowels and singing "Happy Birthday" depending on whether they are using their left or right CI. Electrode insertion depth variability across ears may be one cause of this difference, given that differences in stimulation location cause a shift in pitch perception in single-channel studies. Because of the tight link between perception and production, such shifts in perceived pitch may lead to productions that differ in F0 as well. In this study, we aimed to investigate the role of insertion depth on this production of different vocal pitches when using the right versus the left CI.

Design: Eleven bilateral CI users participated in this study. In order to mimic differences in insertion depth, four electrodes were deactivated, either at the apical or the basal end of the array. Data were collected for two vocal tasks: producing a sustained vowel and singing "Happy Birthday."

Results: The results indicated that participants did not change their vocal pitches in response to different simulated insertion depth. The difference between apical and basal conditions was not significant.

Conclusions: The results of this study suggest that insertion depth differences across ears cannot explain the shift in vocal pitch that occurs when bilateral CI users produce sustained vowels and sing "Happy Birthday" when using one CI versus the other.

Poster #: 31

From the Electrode-Neuron Interface to Frequency Selectivity and Speech Recognition

Meisam Arjmandi, PhD; Kelly Jahn, AuD, PhD; Kevin Franck, PhD; Julie Arenberg, PhD, Harvard Medical School-Massachusetts Eye and Ear, Boston, MA

Objectives: The purpose of this study was to analyzing a big data set obtained from several studies from our lab to investigate (a) the quality of electrode-neuron interfaces (ENIs) in adults and children with cochlear implants (CIs), and (b) how the variability in ENI quality relates to variability in their auditory spectral resolution and speech recognition outcomes.

Design: Data were collected over the last several years and include thirty eight listeners with CIs (22 adults and 16 children) with the Advanced Bionics device. Nineteen participants were bilaterally implanted (6 adults). Focused thresholds were measured for 14 of 16 electrodes (E2-E14), using the steered quadrupolar electrode configuration, known to be sensitive to electrode-to-modiolus distance, the integrity of the nearby auditory

neurons, and/or bone and tissue growth in the cochlea after surgery. An electrode-sweep procedure was used with a focusing coefficient of 0.9. The frequency selectivity of electrodes were evaluated by measuring psychophysical tuning curves through either a sweep or two-interval, two-alternative, forced choice (2IFC) procedure. Speech recognition was assessed by evaluating listeners' performance in vowel identification as a good probe for spectral perception. Listeners were asked to identify medial vowels in the /hVd/ context for ten vowels, presented at 60 dB SPL in quiet and with a +10 signal to noise ratio level of 4-talker babble.

Results: Findings showed that the high, average thresholds corresponded with poorer vowel identification scores. The apical, middle, and basal electrode thresholds contributed to frequency selectivity and vowel identification in both adults and pediatric CI users. The profile shape of the thresholds across the CI arrays for individuals was classified based on the fit of a polynomial, and were predictive of the patterns of errors in vowel identification in certain direction of vowel height and vowel advancement. The average thresholds were higher for CI users with longer durations of deafness. Auditory perception thresholds were lower for children than those of adult CI users. Average focused thresholds and profile classifications were different between ears of individuals who were bilaterally implanted, suggesting an asymmetric contribution of the thresholds to peripheral and central auditory processing.

Conclusions: The findings reveal that the quality of ENIs is an important factor in explaining spectral resolution and speech recognition in listeners with CIs. Better understanding connection between speech acoustics, the quality of ENIs, the spectral resolution ability, and speech recognition is needed to improve CI programming strategies and effective clinical recommendations tailored for individual CI users.

Poster #: 32

A Vocoder Study Evaluating the Effects of Transposition

Hannah E Staisloff, BS; Justin Aronoff, PhD, University of Illinois at Urbana-Champaign, Champaign, IL

Objectives: Listening with two ears can yield considerable improvements in localizing sounds and understanding speech in noisy environments. However, bilateral cochlear implant (BiCI) users do not receive the full benefits of having two ears. These reduced binaural benefits contribute to their difficulties in complex listening environments. Currently, BiCIs are programmed in clinics based on the relative distance of a given electrode from the end of the electrode array. However, due to inconsistent auditory nerve cell survival and insertion depth differences across ears, the electrodes in the left and right array are often not the optimal ones to pair together. As such, current methods can potentially result in pairings of electrodes that result in suboptimal binaural benefits. This suggests that there is a need to change how BiCI devices are programmed, creating personalized programs that optimally pair electrodes across ears. Although customized programs can be created by altering the frequency regions encoded by each electrode to match electrodes across the array, with such an approach some electrodes near the end of one or both arrays will be unmatched. However, simply not stimulating these unmatched electrodes will result in the loss of spectral information. One way of combating this problem may be through moving the information normally encoded by those unmatched electrodes to the next available matched electrode, a process called transposition. This study will determine the impact of transposition on bilateral performance and binaural benefits for normal hearing listeners using a vocoder.

Design: Three experiments with the same group of normal hearing participants were conducted using vocoders with and without transposition. Experiment 1 evaluated performance on a collocated speech and noise task. Experiment 2 evaluated binaural benefits for speech perception in noise. Experiment 3 evaluated binaural benefits on a localization task.

Results: Preliminary results will be discussed.

Conclusions: The results of this study will potentially help in developing new techniques to improve CI users' performance. It will also further the understanding of how transposition can affect binaural abilities in HA users.

Poster #: 33

Cochlear Implant Users' Voice Quality
Simin Soleimanifar, PhD; Pasquale Bottalico, PhD; Silvia Murgia, PhD; Justin Aronoff, PhD, Department of speech and Hearing Science, Collage of Applied Health Science, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL

Objectives: While having a hearing loss can cause degradation of vocal control, a cochlear implant (CI) can potentially help counter that effect. However, CIs are typically shallowly inserted, which may result in CI users perceiving the pitch of their voice to be much higher than it does, causing them to compensate and push their voice outside of their normal pitch range, potentially causing decreases in voice quality. In this retrospective study, we aimed to investigate CI users' voice quality with and without their CI.

Design: Twenty-five postlingually_deaf_adults with_bilateral_cochlear implants were included in this study. Two listening conditions were tested: both cochlear implants off and both cochlear implants on. Participants were asked to produce a sustained /a/. The median of Pitch Strength and Smooth Cepstral Peak Prominence (CPPS), two measures of voice quality, were calculated.

Results: The result indicated_that CPPS was significantly higher in the off condition (95% confidence interval: -3.5 to -.4 dB). The difference was not significant for pitch strength (95% confidence interval: -.07 to .01).

Conclusions: The results suggest that CI users' voice quality decreases when they use their CIs, suggesting potential long-term detrimental effects on voice quality from CI use. Future research should investigate how to mitigate these effects.

ELECTROPHYSIOLOGIC RESPONSES

Poster #: 34

The Electrophysiological Masking Level Difference: Age, Hearing and Cognitive Predictors
Lauren Dillard, AuD; Cynthia Fowler, PhD, University of Wisconsin-Madison, Madison, WI

Objectives: The masking level difference (MLD) is an auditory late latency response (P2) that measures the ability of the auditory system to separate signals from noise using both ears. The purpose of this study was to determine the effects of age, hearing (audiometric, self-reported, speech in noise) and cognitive performance on the speech-token-elicited electrophysiological MLD.

Design: Participants (n=48; age range 19-87) underwent testing, which included otoscopy, tympanometry (screening), pure-tone audiometry (250 – 8000 Hz), self-reported hearing handicap (hearing handicap inventory

(HHI), and in adults aged 50+, the speech in noise (SPIN) high- and low-context sentences. The electrophysiological MLD was measured via scalp electrodes on the vertex (Cz, non-inverting input), right and left mastoid (A2 and A1, inverting input) and forehead (Fpz, ground) using the speech tokens /ah/ and /wa/ in a background of 65 dB HL speech noise. The MLD was derived from SoNo-SpNo.Participant age was categorized as follows, young (19-27, n=21), young-older (52-69, n=15), and older (70-87, n=12). Pure tone averages (PTA) were calculated in each ear from frequencies 0.5-4.0 kHz and the presence of hearing loss was defined as PTA > 25 dB in either ear. Hearing handicap was defined as an HHI score > 8. SPIN scores were averaged across both ears for high- and low- context sentences. Cognitive performance was measured with the Montreal Cognitive Assessment (MoCA). SPIN (high-, low-context) and MoCA scores were transformed into binary variables via median splits. The MLD was calculated by subtracting the level (dB SPL) of the SoNo from the SpNo waveform. For each potential predictor, differences among groups are presented as p-values (alpha=0.05) ascertained from ANOVA and t-tests. Pearson correlation coefficients (r2) are presented for continuous variables.

Results: For tokens /wa/ and /ah/, the mean (SD) MLD for age groups were: /ah/ young: 9.6 (2.8), young-older: 5.1 (3.4), older: 2.5 (2.8); /ah/ young: 7.0 (3.9), young-older: 4.1 (3.0), older: 3.3 (3.7). ANOVAs showed significant differences by age group for the token /ah/ ($p<0.01$) but not /wa/ ($p=0.08$). For hearing measures, t-tests showed significant differences in those with (vs without) audiometric hearing loss for /ah/ ($p<0.01$) and /wa/ ($p=0.04$) but no significant differences in those with (vs without) self-reported hearing handicap (/ah/, $p=0.49$; /wa/, $p=0.76$). There were not significant differences in high vs low performers (determined via median split) on SPIN high- (/ah/, $p=0.64$; /wa/, $p=0.60$) and low- (/ah/, $p=0.48$; /wa/, $p=0.85$) context sentences or cognitive performance (/ah/, $p=0.60$; /wa/, $p=0.15$). When hearing-related predictors were treated continuously, PTA showed a strong correlation with the MLD elicited with /ah/ ($r2=0.57$) but not /wa/ ($r2=0.20$). There were low correlations ($r2< 0.29$) of the MLD with the HHIE, SPIN high- and low-context sentences. However, PTA was strongly correlated with SPIN high- ($r2=0.72$) and low- ($r2=0.73$) context sentences and HHI ($r2=0.55$). Future research will focus on interactions of age and potential predictors.

Conclusions: Preliminary findings suggest that age and audiometric hearing are related to the MLD but suggests that self-reported hearing handicap, speech in noise, and cognitive performance are not.

Poster #: 35

Preceding Context Influence on Adaptation in Vowel-Evoked Envelope Following Responses
Vijayalakshmi Easwar, PhD; Lauren Chung, University of Wisconsin Madison, Madison, WI

Objectives: Evoked potentials such as envelope following responses (EFRs) require averaging over multiple stimulus trials to reduce noise and improve response detection. Repeated stimulus presentation over multiple trials could lead to reduced neural responsivity due to adaptation. Adaptation is evident in vowel-evoked EFRs as a reduction in response amplitude at the fundamental frequency of voice. While adaptation may be an indicator of more efficient processing for incoming stimuli, it may be counterproductive for improving response detection via averaging. Because EFRs are continuous responses that are commonly recorded without interstimulus intervals, one way to reduce adaptation in vowel-evoked EFRs is to interleave vowel stimuli with other “context” phonemes. The present study we evaluate if adaptation in vowel-evoked EFRs can be reduced with (i) the use of preceding context phonemes and (ii) altering the predictability of the context phonemes. It was hypothesized that adaptation will be lower with the use of context phonemes, especially with reduced predictability.

Design: EFRs were elicited by the first (F1) and second and higher formants (F2+) of the male-spoken vowel /i/ presented at 70 dB SPL. The stimulus /i/ was presented in four conditions: a No-context that entailed four repeated presentations of /i/, a single-context condition that entailed the use of the phoneme /s/ before each of the four repetitions of /i/, a multiple-context condition that entailed the use of phonemes /u/, /a/, /sh/ and /s/ before each of the four repetitions of /i/ and a random-context condition that entailed the randomized presentation of phonemes /u/, /a/, /sh/ and /s/ before each of the four repetitions of /i/. EFRs were extracted from single-channel electroencephalogram recorded between the vertex and nape of the neck when stimuli were presented monaurally. EFRs were averaged over 250 sweeps per condition while maintaining the temporal order of the four repetitions of /i/. Conditions were counterbalanced across participants. Data has been gathered in 17 of the intended 25 young adults with normal hearing.

Results: Repeated measures analysis of variance on preliminary data indicated a 3-way significant interaction between the stimulus condition, vowel temporal order and the formant. Post-hoc analyses indicated an effect of vowel temporal order for F2+- elicited EFRs in the no-context condition. On average, EFRs were larger in amplitude by 19.6 nV when elicited by the first /i/ compared to those elicited by the second one in the no-context condition. No effect of temporal order was found for F2+-elicited EFRs in the three conditions with a context. Further, no effect of temporal order was found for F1-elicited EFRs in any of the conditions.

Conclusions: Preliminary data suggest that repeated stimulus presentations tended to decrease the amplitude of vowel-evoked EFRs only when there was no preceding context, and only when they were elicited by F2+. While the use of even one context phoneme reduced the degree of adaptation, additional analysis is necessary to infer if the benefit of reduced adaptation with a context phoneme offsets any reduction in EFR amplitude due to potential forward masking.

Poster #: 36

Behavioral and Electrophysiological Amplitude Modulation Measurements in Cochlear Implant Users
Brittney Lea Carter, AuD; Jeffrey Skidmore, PhD; William Riggs, AuD, Department of Otolaryngology - Head and Neck Surgery, The Ohio State University, Columbus, OH
Monita Chatterjee, PhD, Boys Town National Research Hospital, Omaha, NE, Omaha, NE
Shuman He, MD, PhD, Department of Otolaryngology - Head and Neck Surgery, The Ohio State University, Columbus, OH

Objectives: Speech perception outcomes in cochlear implant users are associated with temporal processing abilities. Amplitude modulation detection can be used to measure the temporal acuity of the auditory system. The potential effect of temporal processing by the auditory nerve on the perception of amplitude modulation in cochlear implant users remains poorly understood. In this study, we used a within-subject design to investigate the association between behavioral and peripheral electrophysiological measures of amplitude modulation sensitivity with the overall goal of determining how much variation in processing at the perceptual level can be explained by processing at the peripheral auditory nerve. The study hypothesis was that poorer sensitivity to amplitude modulation at the auditory nerve would correlate with poorer behavioral sensitivity.

Design: To date, six post-lingually deafened cochlear implant users ranging in age between 37 to 69 years (mean: 56 years; SD: 14 years) have participated in this study. For each subject, one ear was tested. All subjects were implanted with a Cochlear™ Nucleus® device with full electrode insertion. For each subject, electrically evoked compound action potentials were measured for a 2000 pps pulse train sinusoidally amplitude-modulated at 20 Hz and 100 Hz, with 100% modulation depth, at two electrode locations. The modulated response

amplitude ratio was used to quantify the sensitivity of the auditory nerve to amplitude modulation cues. It was defined as the ratio of the difference in the maximum and the minimum amplitude of the electrically evoked compound action potential measured for the pulse train compared to that measured for the single pulse. Behavioral sensitivity to amplitude modulation was evaluated using a three-alternative, forced-choice paradigm for the same electrodes at which electrically evoked compound action potentials were measured. Stimuli were 2000 pps pulse trains sinusoidally amplitude-modulated with 80% modulation depth, with stimulus level roving randomly between -10% and +10% of the dynamic range. Two alternatives were amplitude-modulated at the test rate (i.e., 20 or 100 Hz) and the third alternative was amplitude-modulated at one of eight individually selected contrast rates. The highest contrast rate ranged from 1.4-5 times the test rate. Ten trials were presented for each contrast rate, for a total of 80 randomized trials. This process was repeated twice for each test rate. The percent correct at each contrast rate was averaged across trial sets and then fit with a psychometric function. Behavioral amplitude modulation detection thresholds were defined as the frequency estimating 79.4% correct in the psychometric function. Data collection and correlational analyses between behavioral and electrophysiological measurements were performed separately for the two test rates.

Results: Our preliminary results show no significant correlations between behavioral amplitude modulation detection thresholds and electrophysiological modulated response amplitude ratios at either test rate.

Conclusions: This null finding could be due to the relatively small sample size included in the preliminary data analysis. Potential aging effect on amplitude modulation detection thresholds, as well as within-subject comparisons for results recorded at different electrode locations, will be investigated with additional data.

HEARING LOSS / REHABILITATION

Poster #: 37

Hearing Impairment and Risk of Depression in Older Adults

Danielle S. Powell, AuD; Joshua Betz, MS, Johns Hopkins University, Baltimore, MD
Kristine Yaffe, MD, University of California San Francisco, San Francisco, CA
Stephen Kritchevsky, PhD, Wake Forest University, Winston-Salem, NC
Elsa Strotmeyer, PhD, University of Pittsburgh
Eleanor Simonsick, PhD, National Institute on Aging
Frank Lin, MD; Alden Gross, PhD; Jennifer Deal, PhD, Johns Hopkins University, Baltimore, MD

Objectives: Whether hearing impairment (HI) is associated with depressive symptoms remains disputed for older adults, in part due to varying definitions employed, use of subjective hearing measures, or cross-sectional analysis. Our objective is to investigate if hearing impairment is associated with higher prevalence and incidence of depressive symptoms in older adults. We hypothesize hearing impairment is associated with greater prevalence and increased incidence of clinically significant depressive symptoms in older adults.

Design: We studied 1936 men and women (mean age 74.1 years, 41.7% black race) enrolled in the prospective Health, Aging and Body Composition study. Hearing thresholds at 500-4000 Hz were averaged to create a pure tone average (PTA) and HI was defined using clinical cutpoints in the better-hearing ear. Depression was measured using the Center for Epidemiologic Studies Depression Scale (CES-D) or the CES-D 10, a revised 10 question scale depending on visit. Linear mixed effects models with random intercepts and slopes were used to estimate difference in rates of change in depressive symptomatology by hearing status over nine years. Cox

proportional hazard models were used to examine the association between HI and incident depression defined as change in CES-D score >=10 points.

Results: In models adjusted for demographic and clinical covariates, participants with HI demonstrated a higher baseline prevalence of depressive symptoms compared to those with normal hearing (20.7% vs. 8.4%). Rates of change did not differ by HI status. Participants with moderate or greater HI had an increased risk of 9-year incident depression (HR=1.28, 95% CI: 1.00-1.62) compared to participants with normal hearing.

Conclusions: HI is associated with increased risk of incident depression and a greater overall prevalence of depression compared to normal hearing, underscoring the importance of further research on whether rehabilitative therapies can mitigate this association.

Poster #: 38

Non-otologic Medical Conditions Associated with Hearing Loss and Tinnitus in Veterans

Leslie Diane Grush, AuD, VA RR&D National Center for Rehabilitative Auditory Research, Portland, OR
Kelly Reavis, PhD, VA RR&D National Center for Rehabilitative Auditory Research; Oregon Health & Science University, School of Public Health, Portland, OR
Susan Griest; Samrita Thapa; Wendy Helt, MA, VA RR&D National Center for Rehabilitative Auditory Research, Portland, OR
James Henry, PhD; Sarah Theodoroff, PhD, VA RR&D National Center for Rehabilitative Auditory Research; Oregon Health & Science University, Department of Otolaryngology/Head & Neck Surgery, Portland, OR

Objectives: Hearing loss and tinnitus are common in Veterans; this is typically attributed to noise exposure during military service. Non-otologic medical conditions also contribute to auditory dysfunction, but patterns of comorbidities of auditory dysfunction are currently not well described for young individuals or for Veterans. These associations may be especially important in Veterans, who are more likely than civilians to have chronic medical conditions. Furthermore, prior studies of these associations may not have adequately adjusted for noise exposure. This study describes associations between comorbidities (count and specific disease) and auditory dysfunction in a sample of young, recently separated Veterans.

Design: Audiometric and self-reported questionnaire data were analyzed from a sample of 487 participants in the Noise Outcomes in Servicemembers Epidemiology (NOISE) study. Participants were United States Veterans within approximately 2.5 years of separation from military service. Self-reported history of diagnosed non-otologic medical conditions was collected by questionnaire. Hearing loss was determined by pure-tone audiometric thresholds for low, high, and extended high-frequency ranges. Tinnitus was determined using the Tinnitus Screener. Logistic regression analyses were performed to estimate odds ratios and 95% confidence intervals for medical conditions according to the number of comorbidities on hearing loss and on tinnitus. Covariates were selected a priori using a causal modeling approach, including noise exposure collected using the LENS-Q questionnaire which captures a comprehensive, detailed history of military noise exposure.

Results: 34% of subjects reported no comorbidities, 32% reported one comorbidity, and 34% of subjects reported two or more comorbidities. Compared to Veterans reporting no comorbid medical conditions, Veterans reporting one comorbidity were twice as likely to have low-frequency hearing loss, and those reporting two or more comorbidities were three times more likely to have low-frequency hearing loss. Compared to Veterans reporting no medical comorbid conditions, Veterans with one comorbidity were twice as likely to have tinnitus and those with two or more comorbidities were over three times more likely to have tinnitus.

Conclusions: Non-otologic medical conditions were associated with an increased likelihood of hearing loss and tinnitus in this sample. The study highlights the importance of accounting for noise and other exposures and elucidates the relationships between hearing health and medical conditions in younger Veterans, supporting the need for an integrated health care approach.

Poster #: 39

Is Music Too Loud for Musicians? An Acoustical Environment Survey

Lauren J. Chung; Yuan He, PhD; Sriram Boothalingam, PhD, University of Wisconsin-Madison, Madison, WI

Objectives: Approximately 22 million people in the US are exposed to hazardous noise levels in the workplace. With rigorous rehearsal hours inside and outside the classroom, collegiate level musicians are particularly vulnerable to early-onset noise-induced hearing loss (NIHL). Despite its high prevalence, the literature on the impact of the acoustic environment on hearing is limited due to subjective questionnaires about perceived noise exposure and individual dosimeters that do not provide details of the acoustic environment. In this study, we aim to determine if the sound pressure levels (SPLs) are high enough to raise concern for potential hearing damage in musicians, provide a comparison of the average SPLs across a wider range of music bands, and characterize any differences in the acoustics of different music bands. Based on the average duration of exposure across different groups and instruments, we aim to deduce the safe amount of sound exposure without causing damage to hearing in musicians.

Design: Through a cross-sectional and qualitative design, real-time and average SPLs and overall spectra are acquired for each band affiliated with the UW-Madison School of Music using a calibrated sound level meter. The device is placed in front of the room to ensure consistency across different room dimensions. Considering extraneous factors (instructor talking, breaks), the same ensemble will be measured at least three times to accurately quantify SPLs. Applying the standard noise-exposure metric recommended by the Occupational Health and Safety Administration (OSHA), we will compute the average SPL and duration of daily dosage of noise exposure. This data, including spectra, are used to categorize musicians based on their predicted risk of hearing damage and their primary instrument/band.

Results: Data has been acquired from nine bands and nine different instruments from individual practice rooms thus far. Preliminary results suggest that there is considerable variability among different bands based on the type of instrument, duration of practice, and size of the room. Specifically, individual practice rooms have yielded higher SPLs compared to larger ensembles due to the smaller room volume. Further data and analysis will be presented at the conference.

Conclusions: Prevention is better than a cure, especially when there is no current treatment for NIHL. Our project takes a data-driven approach to identify the hazards of music exposure and educate musicians accordingly. The outcome of this study will extend awareness of hearing conservation and aid musicians, as early as collegiate level musicians, who may be at risk of hearing loss. To extend this awareness, an interactive educational website will be developed based on the data generated. Our results may provide guidelines for immediate implementation of hearing conservation that can help impede NIHL in musicians.

Poster #: 40

Diabetes, Hearing Loss, Race, and Poverty: Lessons from NHANES

Daniel Ricardo Contreras, BS; Zoe Hernandez, BA; Santiago Perez, BS; Matthew Town, PhD; Anne Hogan, PhD, Pacific University, School of Audiology, Hillsboro, OR

Objectives: Numerous studies reveal that health status is impacted by race and income, amongst other variables. This project explores the connection between hearing loss and diabetes in Hispanic patients as compared with other demographic groups, as a function of income. It is hypothesized that Hispanics with lower income will have higher incidence of hearing loss, and untreated or under-treated diabetes, especially as compared to their White, Non-Hispanic counterparts.

Design: For this project, the NHANES data from the 2015-2016 cycle is explored. This cycle contains over 4,000 subject-persons with complete audiometric data for analysis. Statistical analysis includes multivariate correlations and regression to determine the strongest impact on hearing health status, as it relates to race, income, and diabetic status, and their intersection.

Results: The results will discuss the incidence of both hearing loss and diabetes as a function of race and income. Following the trend seen for all areas of healthcare, as social status increases, the incidence of hearing loss and of diabetes, specifically untreated diabetes, will decrease.

Conclusions: In addition to race and income, there are potential cultural and economic impacts leading to decreased healthcare access. Researchers and hearing healthcare providers across the globe must be sensitive to these issues in order to create equitable care and research that is relevant to the broader population.

Poster #: 41

Mentored Student Poster Award

The Laterality of Early Age-Related Hearing Loss and Cognition

Alexander Chern, MD, Department of Otolaryngology-Head and Neck Surgery, Columbia University Irving Medical Center, NewYork-Presbyterian Hospital, and Columbia University Vagelos College of Physicians and Surgeons, New York, New York; Department of Otolaryngology-Head and Neck Surgery, Weill Cornell Medical College and NewYork-Presbyterian Hospital, New York, NY
Alexandria Irace, BA, Department of Otolaryngology-Head and Neck Surgery, Columbia University Irving Medical Center, NewYork-Presbyterian Hospital, and Columbia University Vagelos College of Physicians and Surgeons, New York, NY
Justin Golub, MD, Department of Otolaryngology-Head and Neck Surgery, Columbia University Irving Medical Center, NewYork-Presbyterian Hospital, and Columbia University Vagelos College of Physicians and Surgeons, New York, NY

Objectives: Research studies have demonstrated an independent association between hearing loss and cognition. However, there is minimal and conflicting literature examining the laterality of this association (i.e., if hearing loss of one side contributes to this association more than hearing loss of the other side). The objective of this study is to analyze the association between neurocognitive performance and early age-related hearing loss in the right and left ear. Our hypothesis is that neurocognitive performance is associated with early age-related hearing loss of both the right ear and left ear (i.e., no side-specific association).

Design: Subjects included 5190 participants aged 50 or older from the general Hispanic population who underwent audiometric testing in a US multi-centered epidemiologic study (Hispanic Community Health Study [HCHS]). The primary exposure was hearing in the right and left ear, measured by 4-frequency pure-tone average (PTA) at 500, 1000, 2000, and 4000 Hz. The primary outcome was neurocognitive performance, measured by the Digit Symbol Substitution Test (DSST), Word Frequency Test, Spanish-English Verbal Learning Test (SEVLT) 3 Trials, SELVT Recall, and Six-Item Screener. Higher scores indicate better neurocognitive performance. Linear regression was performed to assess the cross-sectional association between cognitive performance and hearing in each ear, adjusting for potential confounders (age, sex, education, cardiovascular disease, and hearing aid use).

Results: Among 5190 individuals, mean (standard deviation) age was 58.3 (6.2) years; 3198 (61.6%) were women. Mean (standard deviation) pure-tone average was 20.2 (11.7) dB in the right ear and 20.2 (12.3) dB in the left ear Multivariable regression adjusting for confounders demonstrated significant associations between all cognitive tests and early age-related hearing loss in both the left and right ear. For every 10-dB worsening in left ear PTA, there was a significant decrease in cognitive performance as measured by DSST score (1.12-point decrease, 95% confidence interval [CI]: 0.61-1.62), Word Frequency Test (0.76-point decrease, 95% CI: 0.44-1.08), SELVT 3 Trials (0.67-point decrease, CI: 0.43-9.92), SELVT Recall (0.4-point decrease, CI: 0.26-0.53), and Six-Item Screener (0.06-point decrease, CI: 0.02-0.1). For every 10-dB worsening in right ear PTA, there was a significant decrease in cognitive performance as measured by DSST score (1.22-point decrease, CI: 0.7-1.74), Word Frequency Test (0.62-point decrease, CI: 0.28-0.95), SELVT 3 Trials (0.64-point decrease, CI: 0.39-0.9), SELVT Recall (0.41-point decrease, CI: 0.27-0.55), and Six-Item Screener (0.05-point decrease, CI: 0.01-0.1).

Conclusions: Worsening hearing loss in both the right and left ear was associated with decreased performance across all neurocognitive tests. No laterality was demonstrated in the association between early age-related hearing loss and neurocognitive performance. These results are important for understanding of the laterality of central auditory connections.

Poster #: 42

The Longitudinal Association of Subclinical Hearing Loss with Cognition

Alexander Chern, MD, Department of Otolaryngology-Head and Neck Surgery, Columbia University Irving Medical Center, NewYork-Presbyterian Hospital, and Columbia University Vagelos College of Physicians and Surgeons, New York, NY; Department of Otolaryngology-Head and Neck Surgery, Weill Cornell Medical College and NewYork-Presbyterian Hospital, New York, NY
Alexandria Irace, BA, Department of Otolaryngology-Head and Neck Surgery, Columbia University Irving Medical Center, NewYork-Presbyterian Hospital, and Columbia University Vagelos College of Physicians and Surgeons, New York, NY
Rahul Sharma, BS, Department of Otolaryngology-Head and Neck Surgery, Columbia University Irving Medical Center, NewYork-Presbyterian Hospital, and Columbia University Vagelos College of Physicians and Surgeons, New York, NY
Yuan Zhang, MS; Qixuan Chen, PhD, Department of Biostatistics, Mailman School of Public Health, Columbia University, New York, NY
Justin Golub, MD, Department of Otolaryngology-Head and Neck Surgery, Columbia University Irving Medical Center, NewYork-Presbyterian Hospital, and Columbia University Vagelos College of Physicians and Surgeons, New York, NY

Objectives: An independent association has been observed between age-related hearing loss and cognition. However, few studies have investigated whether the association exists among those with subclinical hearing loss, defined as ≤25 dB, i.e., hearing loss below the threshold for which hearing aids are typically recommended. Our objective was to examine the longitudinal association between subclinical hearing loss and neurocognitive performance. As a reference, we also examine the longitudinal association among those with all ranges of hearing.

Design: A longitudinal analysis was conducted among 2115 subjects who underwent audiometric testing in a US multi-centered epidemiologic cohort study (Health, Aging, and Body Composition [Health ABC], a biracial cohort [white and black] of well-functioning adults aged 70–79 years). The primary exposure was hearing in the better ear, as determined by the average threshold for pure tone frequencies 500, 1000, 2000, and 4000 Hz. Subclinical hearing loss was defined as hearing ≤25 dB. Audiometry was conducted at year 5. The primary outcome was neurocognitive performance, measured by the Digit Symbol Substitution Test (DSST, a speed/attention test), Modified Mini Mental State Examination (3MS, a global cognitive function test), and the CLOX1 (an executive function clock drawing test). Higher scores indicated better neurocognitive performance. Linear mixed models were performed to assess the longitudinal association between hearing and cognitive performance, adjusting for potential confounders (age, gender, race, education, smoking status, hypertension, diabetes, stroke, and hearing aid use). The interaction between hearing and year was included in the model to allow the association between hearing and cognitive performance to vary across time. Models were fit first among all individuals and then among individuals with subclinical hearing loss only.

Results: Among 2115 individuals, mean (SD) age was 73.5 (2.9) years; 1105 (52.3%) were women. Mean (SD) pure-tone average of the better ear was 30.0 (13.1) dB. Follow-up ranged from 3 to 16 years (mean = 9.1 years). Among all participants, worse hearing was associated with a significantly steeper decline in cognitive performance as measured by the DSST (0.054-point/year steeper decrease per 10 dB worse hearing, 95% confidence interval [CI]: 0.026-0.082) and 3MS (0.043-point/year steeper decrease per 10 dB worse hearing, CI: 0.025-0.062), but not CLOX1. Among those with subclinical hearing loss (≤25 dB), worse hearing was associated with a significantly steeper decline in cognitive performance as measured by DSST (0.120-point/year steeper decrease per 10 dB worse hearing, CI: 0.013-0.228) and 3MS (0.063-point/year steeper decrease per 10 dB worse hearing, CI: 0.003-0.130), but not CLOX1.

Conclusions: Among those with subclinical hearing loss, worse hearing was associated with steeper declines in cognitive performance over time. The relationship between hearing loss and cognition may begin at earlier levels of hearing loss than previously recognized.

Poster #: 43

Sleep Disturbances and Hearing Loss in Older Adults

Kening Jiang, Cochlear Center for Hearing and Public Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Adam Spira, PhD, Department of Mental Health, Johns Hopkins Bloomberg School of Public Health; Department of Psychiatry and Behavioral Sciences, Johns Hopkins School of Medicine; Johns Hopkins Center on Aging and Health, Baltimore, MD
Nicholas Reed, AuD, Cochlear Center for Hearing and Public Health, Johns Hopkins Bloomberg School of Public Health; Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health; Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins School of Medicine, Baltimore, MD

Frank Lin, MD, PhD, Cochlear Center for Hearing and Public Health, Johns Hopkins Bloomberg School of Public Health; Department of Mental Health, Johns Hopkins Bloomberg School of Public Health; Johns Hopkins Center on Aging and Health; Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health; Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins School of Medicine, Baltimore, MD
Jennifer Deal, PhD, Cochlear Center for Hearing and Public Health, Johns Hopkins Bloomberg School of Public Health; Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health; Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins School of Medicine, Baltimore, MD

Objectives: Understanding risk factors of hearing loss is important. Sleep disturbances are worthy of examination given their high prevalence, modifiable nature, and intensive involvement in disease processes. Sleep disturbances might impair hearing by disturbing energy metabolism and disrupting cochlear blood flow, caused by intermittent hypoxia and elevated cardiovascular risk. Prior studies were conducted generally in small clinical samples and occupational cohorts. To our knowledge, only two cross-sectional population-based studies have investigated this association in adults, though neither study included adults aged 80 or older and was nationally representative. We investigated associations of sleep duration and sleep-disordered breathing with hearing in a nationally representative cohort of U.S. older adults aged 70 and over.

Design: National Health and Nutrition Examination Survey (NHANES) is an ongoing series of cross-sectional surveys. We studied 628 older adults aged 70+ years who were eligible for audiometry from the 2005-2006 cycle of NHANES. Hearing thresholds at 0.5, 1, 2, 4, 6 and 8 kHz were measured using pure tone audiometry. Hearing thresholds were averaged to create speech-frequency (0.5-4 kHz), low-frequency (0.5-2 kHz) and high-frequency (4-8 kHz) pure-tone averages (PTAs) in better-hearing ear, with higher values indicate worse hearing. Sleep duration and signs/symptoms of sleep-disordered breathing (snoring, snorting/stopping breathing and excessive sleepiness) were collected by questionnaire. Multivariable-adjusted linear regression models were used to model the average differences in PTAs by hours of sleep. A three-piece linear spline with knots at 6 and 8 hours were used to allow the association between sleep duration and hearing to differ among those with<6, 6 to 8, and >8 hours of sleep. Associations between signs/symptoms of sleep-disordered breathing and PTAs were modeled using multivariable-adjusted linear regression.

Results: In models adjusting for age, sex, race, education, body mass index, smoking, occupational exposure to noise, hypertension, diabetes, and stroke, when sleep duration exceeded 8 hours, every one-hour increase in sleep duration was associated with a 2.98 dB HL (95% CI: 0.05, 5.91) increase in high-frequency PTA, indicating poorer high-frequency hearing. No associations were observed between sleep-disordered breathing and hearing.

Conclusions: Among older adults who sleep for >8 hours, longer sleep duration is associated with poorer high-frequency hearing. However, whether this association is causal or due to a shared underlying disease process is still unclear. Future longitudinal studies are needed to investigate the mechanism and establish the temporal relationship between sleep and hearing among older adults.

Poster #: 44

Validation of the Brief ICF Core Set for Hearing Loss

Elin Karlsson, MS, Audiological Research Centre, Faculty of Medicine and Health, Örebro University, Örebro, Sweden

Elina Mäki-Torkko, MD, PhD, Audiological Research Centre, Faculty of Medicine and Health, Örebro University, Örebro, Sweden
Stephen Widén, PhD; Johanna Gustafsson, PhD, School of Health Sciences, Faculty of Medicine and Health, Örebro University, Örebro, Sweden
Vinaya Manchaiah, AuD, PhD, Department of Speech and Hearing Sciences, Lamar University, Beaumont, TX
Faheema Mahomed- Asmail, AuD, PhD; De Wet Swanepoel, AuD, PhD, Department of Speech-Language Pathology and Audiology, University of Pretoria, South Africa
Krishna Yerraguntla, PhD, Department of Speech and Hearing, Manipal College of Health Professions, Manipal Academy of Higher Education, Manipal, India
Sarah Granberg, AuD, PhD, School of Health Sciences, Faculty of Medicine and Health, Örebro University, Örebro, Sweden

Objectives: The international classification of functioning disability and health (ICF) was endorsed by World health organization (WHO) and is a classification with a bio-psycho-social approach to functioning and disability and health. To make the classification more easy to use, ICF core sets for specific health conditions are developed. The ICF core sets for hearing loss was developed in 2012. There are two core set s for hearing loss, the comprehensive core set that includes all relevant ICF categories for hearing loss, and the Brief core set which is more compressed version. The ICF core sets for hearing loss are not yet validated, which is the final step when developing core sets. When validated, the core sets for hearing loss can be used as a tool in hearing rehabilitation and research. The core set can be used as a foundation when identifying problem situations and defining rehabilitation goals and can be used as evaluation after an intervention. The aim of the study is to test the psychometric aspects content validity and construct validity of the Brief ICF core set for hearing loss.

Design: MaterialsThe Brief ICF core set for hearing loss which consists of 27 categories and includes categories about body functions, body structures, activity and participation and environmental factors. MethodsThe study is a qantitative international validations study. Adults (≥ 18 years) with verified hearing loss were recruited from clinical populations in India, South Africa, Sweden and US. Structured interviews were performed using the Brief ICF core set and the participants rated their functioning according to ICF-standard 0-5, zero meaning no problem and five a total problem. The option of the digit 9 was also available meaning not relevant. When analysing the content validity descriptive statistics was used and the frequencies for each category were calculated. To analyse the construct validity explorative factor analysis was used.

Results: The result of the explorative factor analysis with ortigonal rotation shows a five factor structure, explaining 67.13 of the variance. The factors show that Brief ICF core set is not unidimentional and only one category, d820 school education, did not fit the model. Cronbach's alpha was 0.98. When calculating the categories marked as "not relevant", d820 school education was not relvenat for 95.6 percent, followed by remunitive empolyment (60.7%), sensations associated with hearing and vestibular function (34.8%), products and technology for communication (27.1%) and community life (19.2%). All respons options(0-5) were used for all categories, except from d820 school education. For most categories, there are no differences in the ratings of functioning or disability between the people with hearing loss regarding the variables degree of hearing loss, gender or age. The only categories where there is a significant difference (<0.005) are b126 temperamnet and personality functions, e310 immediate family, e410 individual attitudes of immediate family members and e460 societal attitudes which all rated as more important with increasing hearing loss. There was a difference in ratings between men and women for the category d850 remunerative employment where men rate it as harder to take part in working life.

Conclusions: The categories of the Brief ICF core set seem to be valid internationally. The category d820 school education is a bit problematic. Thus, we suggest the use of a higher level ICF definition instead, in order

to broaden the definition to include higher education. This study contributes to the validation of ICF core sets for hearing loss and confirms the content and construct validity. The core set is valid to use in hearing rehabilitation and research. Further validation studies of the comprehensive core set and in other contexts are still needed.

Poster #: 45

Severe and Profound Hearing Loss: What is Best Practice?
Laura Turton, MS, Member of the British Academy of Audiology, Warwick
Bernadette Fulton, MS, Phonak Communications AG, Murten

Objectives: Adults with severe and profound hearing loss present us with many challenges in the audiology clinic. There are no clinical guidelines for these clients. Often routine practices of care, even with excellent quality of execution, fail to produce the outcomes which clients hope for and the clinician expects. Sometimes the results of amplification, when accepted practice for those with mild to moderate hearing loss, fails to meet the needs of adults with severe and profound hearing loss. For example, a manufacturer proprietary fitting rationale may deliver comfort and sufficient audibility to achieve immediate acceptance by a new hearing aid user, but may under-fit a severe and profound hearing losses. There is a need to understand best practices for severe and profound hearing loss and identify some directions for future research.Internationally, there are many general guidelines for the assessment and audiological managementfor all adults with hearing loss. Rarely, if ever are people with a severe and profound hearing loss referred to specifically in any of these guidelines.

Design: In response to this a new guideline has been created on the topic of severe and profound hearing loss and amplification. The guidance is not a systematic review but identifies the best available evidence to develop key recommendations for audiological management. Where such evidence is insufficient, expert opinions will be offered, based on clinical experience with this population.

Results: The process of developing the guidance has highlighted the paucity of high quality evidence available to those audiologists who work with adults with severe and profound hearing loss aspiring to evidence based practice. The scientific literature offers weak evidence for the audiological care of these adults especially those who continue to rely on conventional amplification. The guidelines identify specific actions which audiologists can implement to improve outcomes for adults with severe and profound hearing loss.

Conclusions: This paper will familiarize attendees with the new guidelines. It will highlight some examples of the special considerations and practices required to optimize the outcomes for adults with severe and profound hearing loss and their communication partners and outline some of the key recommendations made in the guidelines. It will introduce a new tool to inform best practices specific to the audiologic management of adults with severe and profound hearing loss with conventional amplification. These recommendations can be implemented immediately by audiologists who care for these adults.

HEARING SCIENCE / PSYCHOACOUSTICS

Poster #: 46

COL11A1 Knockdown Zebrafish Model for Syndromic and Nonsyndromic Hearing Loss

Makenna Jaimason Hardy, MS, Boise State University, Boise, ID
Jonathon Reeck, PhD, Facible Biodiagnostics, LLC, Meridian, ID
Ming Fang, PhD, Beigene Pharmaceuticals, Shanghai
Julia Oxford, PhD, Boise State University, Boise, ID

Objectives: Mutations and single nucleotide polymorphisms in the gene encoding Collagen XI alpha one chain (COL11A1) protein can play a role in hearing and balance dysfunction as seen in disorders such as Stickler and Marshall Syndrome and nonsyndromic hearing loss DFNA37. Here we explore the role of COL11A1 zebrafish orthologue Col11a1a in the inner ear. We hypothesize Col11a1a is involved in the development and maintenance of sensory hair cells responsible for mechanotransduction in hearing and balance function.

Design: A Col11a1a knockdown zebrafish model (Col11a1a+/-) was generated using CRISPR/Cas9 gene editing. Wildtype and Col11a1a+/- embryos were analyzed and compared for otic abnormalities. In situ hybridization, immunofluorescence, and scanning electron microscopy techniques were implemented to observe normal Col11a1a expression and the effects when the expression was knocked down (Col11a1a+/-).

Results: We found that Col11a1a was expressed in the developing otic vesicles and sensory hair cells, specifically, expression along kinocilia. The knockdown model of Col11a1a resulted in abnormal otic vesicle structure including abnormally shaped opening, shortened kinocilia, and abnormal otolith formation indicated by incorrect number and size.

Conclusions: This is the first report of Col11a1a in the hair cells of the zebrafish ear. This research highlights the importance of Col11a1a in the development and structure of the inner ear as a whole including the otic vesicle, hair cells, kinocilia, and otolith formation.

Poster #: 47

Listening in 2020 Survey: Masks, Speech Understanding, and Listening Effort
Karen S. Helfer, PhD; Sara Mamo, PhD; Michael Clauss, PhD; Silvana Tellerico, University of Massachusetts Amherst, Amherst, MA

Objectives: This presentation describes results of a survey conducted in the summer and fall of 2020 to document how face masks affect self-perceived speech understanding and listening effort, in quiet and in noise. Data were analyzed to identify the effects of self-rated hearing, age, and hearing aid/cochlear implant use.

Design: Participants were recruited via Facebook ads and via the Hearing Tracker email list and website. Useable responses were obtained from 1702 adults (1168 individuals 40 years of age or older, 534 individuals 21-35 years of age) residing in the U.S. The survey contained a series of probes focused on three scenarios: running errands/attending appointments outside the home, working outside the home, and socializing face-to-face. Participants indicated (via a Likert scale) how well they could understand what someone was saying, and how much concentration they needed to do so, in each of these scenarios under four conditions: with and without the talker using a face mask, in a quiet place and in a noisy place. The survey also asked about using videoconferencing in quiet and in noise, although those data are not included in this presentation. Participants were invited to add subjective comments about strategies they found helpful when talking to someone wearing a face mask. The text responses were analyzed in the context of age categories and self-rated hearing categories.

Results: Due to a limited number of respondents who indicated that they currently worked outside the home, data from those questions were not included in the analyses. Respondents who indicated their overall hearing ability was “fair” or “poor” reported substantial problems in all situations. Among these participants, middle-aged individuals perceived experiencing more difficulty and needing more effort when communicating with people using face masks, as compared to older adults with fair/poor hearing. Respondents in this hearing category who used hearing aids or cochlear implants reported poorer self-rated speech understanding and greater concentration needed, as compared to non-users of devices. There was little difference in response patterns among younger, middle-aged, and older adults who rated their hearing as “excellent” or “good”, with younger participants reporting more difficulty than middle-aged or older respondents for many prompts. Open-ended comments were coded through an iterative process and broadly aligned with the categories of technology, communication strategies, and self-advocacy. Of note is that many respondents indicated that they moved closer to the talker or asked people to remove their masks in order to better understand messages, raising concerns about safety.

Conclusions: As anticipated, self-perceived communication disruptions caused by face mask use were greater among people with poorer hearing than those who rated their hearing as “good” or “excellent”. Middle-aged people with poorer hearing reported more disruption than older adults in the same hearing categories. Notable was that among people who rated their hearing as “excellent” or “good”, younger adults indicated greater disruptions than middle-aged or older adults. These results suggest that face masks can interfere with speech understanding for individuals spanning the adult age range (work funded by NIDCD R01 12057).

Poster #: 48

Advancing Ecological Validity in Hearing Research - A Consensus Approach
Graham Naylor, PhD, Hearing Sciences, University of Nottingham, UK, Glasgow
Gitte Keidser, PhD, Eriksholm Research Centre, Snekkersten

Objectives: The issue of ecological validity in hearing research is attracting increasing attention, and diverse attempts have been made to achieve it more fully in research study design. The time is ripe to draw these threads together and (if possible) establish some consensus on factors which can affect the ecological validity of hearing-related studies, the state of the art, and fertile areas for further progress.

Design: Sixteen senior researchers from relevant backgrounds in academia and industry participated in a three-day workshop. Based on prepared presentations and pre-submitted responses to specific questions, moderated plenum and break-out discussions addressed the following tasks, all with a focus on hearing-related research:-Define ecological validity-Identify purposes of striving for, and potential beneficiaries of, greater ecological validity -Identify and structure the factors in study design which can affect ecological validity-For each of the above factors, estimate the highest level of ecological validity currently achieved in studies/assessments carried out in the laboratory, the field and the clinic, respectively-Identify emerging research and technology fronts which promise to support increased ecological validity.After the workshop, further offline discussions among all participants led to the formulation of consensus statements on all the above (published in Ear & Hearing Dec 2020).

Results: In outline, consensus was reached on the following:-(definition) In hearing science, ecological validity refers to the degree to which research findings reflect real-life hearing-related function, activity, or participation.-(purposes) A) better understanding the role of hearing in everyday life; B) supporting the development of improved procedures and interventions; C) facilitating improved methods for assessing and

predicting ability to accomplish real-world tasks; and D) enabling more integrated and individualized care.-(influential factors) Design factors can be grouped under sources of stimuli, environment (presentation of stimuli), task, context of participation, and individual factors. Additionally, the mode of outcome measurement itself influences ecological validity.-(current status) While laboratory and field studies can achieve moderate and high levels of ecological validity respectively, clinical assessments generally show lower levels.-Emerging fronts include moving towards truly interactive communication test scenarios, ecological momentary assessment in the field, use of virtual and augmented reality technologies, and continuous capture of environmental or bodily data.

Conclusions: Ecological validity is not a priority for all hearing-related research. We hope that where it is a priority, this work may form the basis for improved approaches to assessing the likely level of ecological validity during study design and data interpretation. Researchers are encouraged to use this to make explicit statements about the purpose of striving for more ecological validity in their research. Taken together, this should enable more efficient progress in the study of how hearing contributes to daily-life function, and of the effects of hearing impairment and interventions.

Poster #: 49

T35 Student Poster Award

Feasibility of a Remote Categorical Loudness Scaling Procedure

McKenna E. Turner, Boys Town National Research Hospital; Universtiy of Minnesota Department of Speech-Language-Hearing Sciences, Waconia, MN
Judy Kopun; Sara Fultz, AuD; Aryn Kamerer; Stephen Neely, PhD; Daniel Rasetshwane, Boys Town National Research Hospital, Omaha, NE

Objectives: Categorical loudness scaling (CLS) measures provide information about an individual's loudness perception across the dynamic range of hearing. CLS has potential clinical value in that it may help hearing professionals select amplification parameters that maximize audibility while avoiding loudness discomfort. However, previous CLS studies have only been conducted in laboratory environments. The objective of this study was to assess the feasibility of an adaptive CLS procedure conducted remotely in a home environment. The ability to replicate CLS measurements under non-ideal listening environments will enhance the ecological validity of loudness measures.

Design: Twenty-one participants (19 - 61 years old) who self-identified as having normal hearing were tested. Equipment was delivered to participants, and included a laptop, headphones, microphone, iPod equipped with a NIOSH sound level meter (SLM) application, and instruction manual. Laboratory staff consented and provided instructions to participants via a video chat platform. Participants calibrated the equipment for sound pressure level prior to data collection. Following a practice run at 2 kHz, participants completed two runs at 1 and 4 kHz. Ambient background noise levels were measured using the SLM application prior to each CLS run. The accuracy of the remote CLS test was compared to that of previous in-laboratory studies using within-run variability, calculated as the interquartile range of the level for each loudness category, and across-run variability, calculated as the mean signed differences (MSDs) between CLS functions. Additionally, preliminary validation was assessed for five participants who took part in both the remote study and a previous in-laboratory study by comparing their CLS functions using MSDs.

Results: Average headphone output levels, as measured remotely by participants, were within 1.5 dB of the calibration tone. Although some ambient noise levels exceeded the pre-established target of 50 dBA SPL, mean ambient noise level was 43.7 dBA SPL. A weak positive correlation between background noise level and CLS threshold ($r = 0.228$; $p = 0.038$) suggests that background noise minimally influenced CLS measurements at low level. Within-run variability for the remote test was similar to that for the in-laboratory study, except at low levels where variability for remote data was lower. Across-run variability for the remote test was poorer than that for the in-laboratory study (average MSD across loudness category = 4.6 and 4.5 dB for the remote test vs. MSD = -0.6 and 0.6 dB for the in-laboratory study, at 1 and 4 kHz, respectively). For the five participants who had previous in-laboratory data, average MSDs across loudness category were -4.8 (range = -12.8 to 2.9) dB and 2.7 (range = -5.4 to 5.9) dB at 1 and 4 kHz, respectively. These MSDs are comparable to those for CLS test-retest reliability.

Conclusions: Our results support the feasibility of conducting CLS remotely. Precise levels can be delivered, and background noise can be monitored during remote data collection. Within-run variability for the remote setting was similar to that for the in-laboratory study. Across-run variability was poorer. Preliminary validation suggests that variability of remote CLS data is within test-retest reliability.

HEARING TECHNOLOGY / AMPLIFICATION

Poster #: 50

From Hearing Loss to Technology Access: A Systematic Review of Telemedicine and Dementia Care

Julie Sunjoo Yi, BS, Johns Hopkins University School of Medicine, Baltimore, MD
Corinne Pittman, BA, Howard University College of Medicine, Washington, DC
Carrie Price, MS, Towson University, Towson, MD
Esther Oh, MD, PhD, Department of Medicine, Division of Geriatric Medicine and Gerontology, Johns Hopkins School of Medicine, Baltimore, MD
Carrie Nieman, MD, Department of Otolaryngology-HNS, Division of Otology, Neurotology & Skull Base Surgery, Johns Hopkins School of Medicine, Baltimore, MD

Objectives: Hearing loss is highly prevalent among persons living with dementia and may impact interactions between patients, care partners, and providers. The COVID-19 pandemic brought a rapid increase in telemedicine for older adults with cognitive impairment. However, relatively little is known regarding the barriers and facilitators to telemedicine for this unique patient population. Encounters that do not adequately account for hearing loss may risk inaccurate understanding of instructions and limit the patient or care partner's ability to enact their treatment plan. Telehealth that is responsive to the technological abilities and preferences as well as the sensory needs of persons living with dementia is critical to advancing access to care.

Design: The study team queried PubMed, Embase, the Cochrane Library, PsycINFO, CINAHL, and Scopus, and ClinicalTrials.gov on May 1, 2020 for studies in English published from January 2010 to May 2020. We conducted a systematic review of articles that investigate the use of telemedicine among older adults with Alzheimer's disease and related dementia (ADRD) or mild cognitive impairment (MCI) that focused on the patient and care partner perspectives. Telemedicine encounter purpose, technological requirements, and findings regarding sensory needs, including hearing loss, were extracted. The Cochrane Collaboration's Risk of Bias Tool was applied for quality assessment.

Results: The initial search yielded 3551 nonduplicate abstracts, from which 90 articles were reviewed and 17 were included. The purpose of telemedicine encounters included routine care, cognitive assessment, and telerehabilitation. Three studies investigated telemedicine delivery in the home. Sixteen studies relied upon support staff and care partners to navigate technologies. Among studies reporting technological difficulties, connection and audio issues were most commonly reported. Six studies reported audio difficulties, with participants reporting difficulty hearing the provider during the telemedicine visits. Five studies excluded participants with visual or hearing impairment due to the potential difficulty of using telemedicine technology in this population. Among studies that did not exclude participants on the basis of sensory impairment, 5 studies reported communication challenges due to hearing loss. No studies reported adapting telemedicine equipment with headsets or amplification devices to mitigate communication challenges due to sensory impairment. Among the domains assessed using the Cochrane Risk of Bias Tool, the 'incomplete outcome data' domain had the greatest number of studies rated as 'high risk' of bias.

Conclusions: Although this review focused on telemedicine, successful delivery of telehealth to older adults with cognitive impairment requires support staff and care partners to navigate technologies and optimize the environment, particularly when delivered in the home. The exclusion of older adults with hearing loss, especially given that it is highly prevalent, in developing telemedicine systems limits the ability to optimize communication for these individuals and may further exacerbate access to care in this population. As in-home delivery of telehealth continues to become a part of routine care, adapting technologies for sensory needs not only presents an opportunity to improve care for older adults with ADRD, but also improve care for 2 out of 3 older adults experiencing age-related hearing loss.

Poster #: 51

Quantifying Hearing Aid Users' Auditory Ecology with a Deep Net

Erik Jorgen Jorgensen, AuD; Dhruv Vyas, MS; Yumna Anwar, BS; Justin Jensen, MA; Octav Chipara, PhD; Yu-Hsiang Wu, MD, PhD, University of Iowa, Iowa City, IA

Objectives: There is increasing interest in quantifying the listening environments of hearing aid users to better understand the effectiveness of hearing aids in the real world. The two common methods used are ecological momentary assessment (EMA) and audio recording. EMA lacks acoustic information and the required sampling can be burdensome for participants. Analysis of audio recordings is time and labor intensive due to the requirement of listening to and labeling the recordings. Methods that can provide analyses of large amounts of audio data without the need for participants to complete EMA or for researchers to listen to and catalogue recordings are of interest. This study investigated the use of a widely available deep neural net to quantify a large data set of audio recordings collected from adult hearing aid users.

Design: Fifty-four adult hearing aid users participated in this study (mean=73.6 years). Participants wore a Language Environment Analysis (LENA) device during waking hours and completed EMAs on a smartphone for five weeks. The LENA recorded continuously during wear time. These audio recordings provided the data set for this study. A subset of recordings of 5-minutes prior to the delivery of an EMA were also extracted and paired with their respective EMA responses. The machine learning algorithm YAMnet was used to classify audio recordings. YAMnet is a deep neural net that was pre-trained using the AudioSet-YouTube corpus, an ontology of 632 audio event classes and 2,084,320 10-second human-labeled sound clips from YouTube. YAMnet uses TensorFlow and AudioSet to label recordings. The output of YAMnet contains five classifiers and confidence estimates for each audio analysis window. Audio recordings were analyzed in non-overlapping 5-minute windows.

Results: 24,552 hours of audio recordings were analyzed by YAMnet. 143 different top classifiers were identified (mean confidence = .51, range 0.07-1.0, sd = .25). After removing classifiers that accounted for less than 1% of listening environments, six classifiers remained. Of these, speech accounted for 52.7%, followed by silence (25.2%), inside small room (9.7%), music (4.9%), vehicle (3.3%), and animal (1.0%). To determine whether participant report was aligned with YAMnet classification, questions on the EMA (n=894) were retrospectively identified where participants and YAMnet reported on the same or similar sound classes. These classes were: speech (speech or not speech), room size (small or large), and location (inside, outside, or vehicle). Match rates were calculated by comparing YAMnet classification to participant response. The match rate is the percent of instances where the YAMnet returned a classifier that agreed with the EMA. Match rate for speech was 95.7%. Match rate for room size identification was 78.3% for small room and 99.7% for large room. Match rate for location identification was 99.3% for outside, 95.75% for inside, and 95.5% for vehicle.

Conclusions: YAMnet data were aligned with prior studies quantifying auditory ecologies using more resource intensive methods. YAMnet data were also aligned with the EMA data from participants. Results from this study suggest that deep neural nets can be used to accurately quantify the auditory ecology of hearing aid users.

Poster #: 52

Acoustic Effects of Combined Microphone Directionality and WDRC Amplification

Varsha Rallapalli, AuD, PhD, Northwestern University, Chicago, IL
Richard Freyman, PhD, University of Massachusetts Amherst, Amherst, MA
Pamela Souza, PhD, Northwestern University, Evanston, IL

Objectives: In hearing aids, fast-acting wide dynamic range compression (WDRC) improves audibility of low-intensity portions of the signal, but can also distort the speech envelope. The distortion with faster WDRC speeds is greater in background noise because the compressor may provide more gain to the noise in the 'dips' of speech, effectively reducing the output signal-to-noise ratio (SNR). However, most of the research focused on the effects of WDRC speed is not representative of real-world listening situations where sound sources are often spatially separated. Moreover, few studies have considered the range of directionality options available to improve the SNR in such listening situations. Therefore, the objective of this study is to examine the combined acoustic effects (envelope distortion and output SNR) of WDRC and microphone directionality on speech in spatially separated noise. This study focuses on a specialized form of microphone directionality (beamformer) that is increasingly being used in modern hearing aids.

Design: Output from a wearable hearing aid is recorded on an acoustic manikin for sentences mixed with multi-talker babble across a range of input SNRs. The target sentence is fixed at 0-degree azimuth and the location of the babble is varied between co-located and spatially separated locations to create different spatial conditions. Hearing aid processing is varied in two dimensions: i) Microphone directionality (omnidirectional vs beamformer), ii) WDRC speed (fast-acting vs slow-acting). Other advanced hearing aid features are turned off. A signal fidelity metric is used to quantify envelope distortion in the processed signal across experimental conditions with respect to a linearly processed signal in quiet. In addition, the long-term output SNR for each processing condition, in a given spatial condition, is computed using a phase-inversion method.

Results: Results to date show greater envelope distortion in the following conditions: with omnidirectional settings compared to beamformers in the spatially separated condition; and with fast-acting WDRC compared to slow-acting WDRC in all spatial conditions. The effect of WDRC speed on envelope distortion is reduced with

the beamformer compared to omnidirectional settings, in the spatially separated condition. Changes in output SNR correspond with changes in envelope distortion across conditions.

Conclusions: The pattern of observed results suggests that the envelope distortion due to fast-acting WDRC reduces when beamformers are used in spatially-separated speech and noise, thereby minimizing the detrimental acoustic effects of fast-acting WDRC in these conditions. Moreover, the results highlight the need to consider different spatial conditions while studying the combined acoustic effects of WDRC and microphone directionality. Clinically, this research has implications for how directionality and WDRC speed should be set to maximize acoustic benefits for hearing aid users in realistic listening conditions. [The research is supported by NIDCD.]

Poster #: 53

Effects of Audiogram Configurations on Output Signal-to-Noise Ratios of Digital-Hearing-Aids

Donghyeon Yun, MS, Department of Speech, Language and Hearing Sciences, Indiana University Bloomington, Bloomington, IN
Yi Shen, PhD, Department of Speech and Hearing Sciences, University of Washington, Seattle, WA
Jennifer Lentz, PhD, Department of Speech, Language and Hearing Sciences, Indiana University Bloomington, IN

Objectives: Compression algorithms in hearing aids may reduce the signal-to-noise ratio (SNR), adversely impacting speech understanding in noisy environments. While the effects of certain compression parameters, including compression ratio and time constants, on the SNR at the output of hearing aids (i.e. output SNR) have been investigated, it is not yet clear whether patients with different degrees and configurations of hearing loss would be equally affected by these adverse effects under standard clinical practice. The purpose of the current study is to investigate effects of audiogram configurations, compression parameters (compression time constants), and environmental factors (input SNR) on output SNR.

Design: KEMAR wearing a clinically available hearing aid (ReSound LiNX Quattro 62) was positioned in the center of a sound-attenuating room, and IEEE sentences in a 20-talker babble noise were presented from 0-degree azimuth through a loudspeaker. The output sound level was at 65 dB SPL. A phase-inversion technique was used to calculate output SNR under the following conditions: 5 input SNRs (-10, -5, 0, 5, and 10 dB), 4 standard configurations of audiograms (moderate, moderate to severe, severe, and steep sloping), and 2 compression speeds (syllabic and slow-acting). Under each condition, the measurement was repeated for 10 IEEE sentences. NAL-NL2 was used to prescribe amplification, and all hearing aid technology options were turned off.

Results: Reduction in SNR was observed in majority of test conditions, except for the lowest input SNR (i.e. -10 dB). Output SNR depended on the audiogram configuration. It was also greater at higher input SNRs and for the slow-acting than syllabic compression. Moreover, a significant two-way interaction between audiogram configuration and input SNR and a significant three-way interaction among audiogram configuration, compression speed, and input SNR were found, suggesting increased distortions created by compression for listeners with severe hearing losses.

Conclusions: Different degrees and configurations of hearing loss were not equally affected by the effects of compression speed and input SNR on output SNR using standard hearing-aid fitting procedures. Thus,

audiometric characteristics, compression time constants, and input SNR should not be considered as independent factors during the fine-tuning of hearing-aid fitting.

Poster #: 54

A Randomized Controlled Trial Using Automated Technology for Improving Ototoxicity Monitoring in VA

Dawn Lynnea Martin, PhD; Keri O'Connell Bennett, AuD; Garnett McMillan, PhD, National Center for Rehabilitative Auditory Research, VA Portland Health Care System, Portland, OR
Angela Garinis, PhD, Oregon Hearing Research Center, Oregon Health & Science University, Portland, OR

Objectives: Determine the relative efficacy of ototoxicity monitoring (OM) administered as automated protocols with the Oto-ID mobile audiometer (A-OM), compared with usual care OM (UC) in VA patients receiving cisplatin-based chemotherapy for the treatment of their cancer. We hypothesized that use of A-OM would improve patients' hearing and health-related quality of life outcomes either through drug-treatment modifications to prevent ototoxic damage or auditory rehabilitation to limit the harmful effects of any new or worsened communication deficit. We further expected that cisplatin patients randomized to A-OM would fair no worse than UC patients in terms of their survival.

Design: Randomized controlled trial contrasting A-OM and UC at up to three program evaluations (PEs) conducted by the study audiologist who is blinded to arm through PE1. PE1 occurs before randomization or cancer treatment; PE2 and PE3 occur during and/or after treatment at 30- and 365-days post-randomization. The A-OM group (N=24) uses Oto-ID to test their hearing before each cisplatin dose. Oto-ID results are sent to the study audiologist for interpretation, follow up and care coordination. The UC group (N=22) receives a consult for OM services through the audiology clinic. Outcomes include hearing shift near each patient's high frequency hearing limit, revised hearing-handicap inventory score, and survival time from the start of treatment. Adherence to national OM guidelines is tracked. Patients' use of aural rehabilitation services and oncologists' use of ototoxicity in treatment decisions are also examined.

Results: Participants were 46 patients (mean age 64.7 years; range 30-78 years) receiving cisplatin-based chemotherapy at the VA Portland Health Care System. Adherence to monitoring prior to each cisplatin dose was 83% among those randomized to A-OM compared with 4.5% in those randomized to UC. Ototoxicity was identified at an overall rate of 46% and 76% at 35 and 365 days post-randomization. A-OM did not substantially improve hearing or self-reported hearing handicap relative to UC; however, neither did it compromise survival. Half of participants in each arm accessed aural rehabilitation services. One in each arm had a documented ototoxicity-related cisplatin dose reduction.

Conclusions: Results show that in a sample of 47 VA cancer patients, UC and A-OM produced similar patient-level OM outcomes. Results also demonstrate that while UC failed to provide the most basic level of OM recommended by audiology governing bodies, A-OM worked well in VA patients when administered on the oncology unit using the Oto-ID. Moreover, auditory impairment was an actionable concern for patients and their oncology providers, the intended end users of OM data. Although necessary for ethical reasons, a limitation of this study is that the PEs used to collect outcome data were also used to make appropriate referrals for otology and/or auditory rehabilitation through VA.

Poster #: 55

Life Course Socioeconomic Status and Hearing Aid Use in ARIC

Julie Sunjoo Yi, BS, Johns Hopkins University School of Medicine, Baltimore, MD
Emmanuel Morales, PhD, Cochlear Center for Hearing and Public Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Joshua Betz, MS, Department of Biostatistics, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Jennifer Deal, PhD; Lorraine Dean, Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Simo Du, Cochlear Center for Hearing and Public Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Adele Goman, PhD, Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Nicholas Reed, AuD; Michael Griswold, PhD, Department of Biostatistics, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Frank Lin, MD, PhD; Carrie Nieman, MD, Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins University School of Medicine, Baltimore, MD

Objectives: Hearing care disparities exist by socioeconomic status (SES), and multiple barriers relate to hearing aid use. Previous studies examining hearing care disparities by SES have largely focused on income and education as measures of SES. However, investigating SES over the life course and its relationship to hearing care in older adulthood may offer a more robust understanding of barriers to hearing care. To measure the association between individual life course SES and hearing aid use, we examined socioeconomic variables collected in the Atherosclerosis Risk in Communities (ARIC) Study baseline visit (1987-1989)/Life Course-Socioeconomic (LC-SES) study (2001-2002) and hearing aid use data collected at visit 6 (2016-2017).

Design: The ARIC Study is a community-based prospective cohort study of 15,792 men and women aged 45 to 64 years in 1987-1989 recruited from 4 US communities. 12,716 ARIC baseline participants were queried about parental and early adulthood SES in the LC-SES study. Participants in this analysis included a subset of the ARIC cohort with hearing loss at visit 6 (_25dB hearing level at 0.5, 1, 2, and 4kHz in the better hearing ear) and hearing aid use and SES data. Childhood SES variables included parental education, parental occupation, parental occupational role, and parental home ownership. Young adulthood SES variables included education, occupation, occupational role, and home ownership. Older adulthood SES variables included household income, occupation, occupational role, and home ownership. Each life epoch was assigned a score ranging from 0 to 5, and then summed to calculate the individual cumulative SES score. Higher values of individual cumulative SES score indicate higher SES. Multivariable-adjusted logistic regression was used to estimate the association between individual cumulative SES and hearing aid use. Covariates included age, hearing loss severity, sex, race/ethnicity, self-reported health, household size, communication function, occupational noise exposure, health insurance, and Wide Range Achievement Test 3 (WRAT3) total score, which was used as a proxy for literacy.

Results: Of the 1,714 individuals in the analytic cohort (median [IQR] age 79.9 [76.7-84.0], 886 [51.7%] women), 524 (30.6%) participants reported hearing aid use. Hearing aid users had higher SES scores across childhood (2.4 [1.4] vs 2.2 [1.4]), young adulthood (3.1 [1.2] vs 2.8 [1.3]), and older adulthood (3.9 [1.2] vs 3.6 [1.3]), compared to participants who did not use hearing aids. In the multivariable logistic regression model, higher individual SES was positively associated with hearing aid use (OR=1.09, 95% CI: 1.03-1.15). Specifically, higher childhood SES was positively associated with hearing aid use (OR=1.12, 95% CI: 1.01-1.24). Both young adulthood (OR=1.03, 95% CI: 0.90-1.18) and older adulthood SES (OR=1.11, 95% CI: 0.98-

1.27) were positively associated with hearing aid use as well. Hearing care disparities by race/ethnicity was prominent, with Black individuals having significantly lower odds of hearing aid use (OR=0.41, 95% CI: 0.23-0.73).

Conclusions: In this community-based cohort of older adults with hearing loss, higher individual life course SES was positively associated with hearing aid use, specifically childhood and older adulthood SES. However, race/ethnicity was the strongest predictor of hearing aid use, even after controlling for SES.

Poster #: 56

Improving Hearing Aid Personalization Algorithm Efficiency with User Preference Correlations

Justin Jensen, MA, University of Iowa Department of Communication Sciences and Disorders, North Liberty, IA
Dhruv Vyas, MS; Yumna Anwar, MS, University of Iowa Department of Computer Science, IA
Erik Jorgensen, AuD, University of Iowa Department of Communication Sciences and Disorders, IA
Octav Chipara, PhD, University of Iowa Department of Computer Science, IA
Yu-Hsiang Wu, MD, PhD, University of Iowa Department of Communication Sciences and Disorders, IA

Objectives: Determining the best hearing aid (HA) configuration among all possible configurations is challenging. Prior research has proposed using machine learning algorithms to evaluate the search space of available configurations by learning from user feedback to converge on an optimal configuration. Our previous study evaluated several HA personalization algorithms and compared their accuracy, consistency, and efficiency in converging to a user's most preferred option. The results indicated that although the best-performing algorithm-the Upper Confidence Bound (UCB) algorithm-could converge accurately and consistently, its efficiency (i.e. the total number of paired-comparisons necessary to identify the best configuration) was not good enough to be used in the real world. The purpose of the present study was to assess whether the efficiency of the UCB algorithm could be improved by incorporating correlations between patterns of preference from a group of users in addition to the feedback directly obtained from the user.

Design: Fifteen HA gain-frequency response configurations were developed using audiometric data from a national health database. Speech was recorded from the output of a HA programmed with each of the 15 configurations and presented to 32 older adults with hearing loss. The participants used a paired comparison paradigm to determine the order and strength of preference for all possible combinations of configurations (105 pairwise comparisons x 4 repetitions). Order of preference was determined using a Borda scoring method, where a configuration's Borda score is the ratio between the number of times it was preferred and the total number of pairwise comparisons for that configuration. Correlated pairs of configurations were identified by computing the Pearson correlation coefficient for all configuration pairs across all 32 users. A positively correlated pair has a correlation coefficient greater than 0.7, and the configurations have similarly high/low Borda scores. Alternatively, a negatively correlated pair has a correlation coefficient smaller than -0.7, and one configuration tends to be liked (high Borda score) while the other is disliked (low Borda score). Correlation results were used to determine how many paired comparisons could be removed from the search space and still yield accurate algorithm convergence. RMS differences between correlated configurations were calculated.

Results: Positively correlated configurations had an average RMS difference of 4.52 dB, with differences driven by mid-to-high frequency bands (1 - 6 kHz). Negatively correlated configurations had an average RMS difference of 9.47 dB, with differences spread across all frequencies. Among the 105 possible pairwise comparisons, 33 correlated pairs of configurations were identified, meaning that the outcome of one trial could

yield multiple conclusions about the outcomes of other pairwise trials. Accordingly, the correct order of a given user's preferences can be determined with only 72 comparison trials compared to the 105 total possible combinations, a reduction of 32%.

Conclusions: Incorporating correlations between user preferences can reduce the search space for an optimal HA configuration by as much as 32%. This can translate to a more efficient convergence of the selection algorithm, although additional research is needed to assess to what degree this reduced search space improves efficiency.

Poster #: 57

Do Patient Traits Predict Post-amplification Changes in Quality of Life?
Lipika Sarangi, MS; Jani Johnson, AuD, PhD, Memphis, TN

Objectives: Hearing loss can have detrimental effects on communicative behavior, social and emotional well-being, and hearing-related quality of life (HRQoL). Research has demonstrated that the use of hearing aids (HAs) can significantly improve patients' HRQoL; however, inter-individual outcomes vary substantially, even when hearing difficulties are similar. There is some suggestion that patient traits might mediate perceived benefits from amplification, yet evidence regarding the effects of these variables on perceived HRQoL is unclear. This research sought to determine the degree that patient traits such as age, hearing ability, working memory, and personality might predict perceived post-amplification change in HRQoL.

Design: Forty-five older adults with bilateral mild-to-moderate hearing loss were recruited from the community to participate in this single-blinded, repeated, crossover trial. As a part of a larger study, participants were fitted with four pairs of HAs: basic and premium from two manufacturers that they wore for one month each in their daily lives. Age, hearing ability (bilateral pure tone average), working memory, and personality were assessed prior to the HA fittings. After each HA trial, participants were asked to report their change in HRQoL compared to no HAs. For analysis, we calculated the aggregate change in HRQoL across all the HAs. Stepwise and then hierarchical regression analyses were performed to identify the extent to which any of these measured traits predicted change in HRQoL.

Results: Results of a backward stepwise regression analysis demonstrated that hearing ability (_=.624, t=5.519, p<.001), Agreeableness (_=.301, t=2.102, p=.042), and Neuroticism (_=.291, t=1.969, p=.056) personality traits were the best predictors of post-amplification changes in HRQoL. Individuals with a greater degree of hearing loss and higher Agreeableness and Neuroticism personality traits tended to have a more positive change in HRQoL after one month of HA use. Controlling for hearing ability, the results of hierarchical regression analysis with these two traits demonstrated that Agreeableness explained only 1% of additional variance in reported post-amplification HRQoL change, which was not statistically significant (R squared change=.014, p=.301). However, when neuroticism was also added, these factors explained 6% of additional variance in the HRQoL outcome. These effects were small but approached statistical significance (R squared change=.060, p=.056).

Conclusions: It is well-known that hearing ability is inversely related to perceived benefit with HAs. Our research supports this notion, as this factor explained 62% of the variance in participants' reported HRQoL benefit from amplification. Some research has also demonstrated that individuals with higher cognition tend to experience more success with amplification. Our results did not demonstrate that working memory, one aspect of cognition, impacted perceived change in HRQoL. When we controlled for the effects of hearing ability,

together with the Agreeableness and Neuroticism personality traits, explained a small additional portion of the variance in perceived change in HRQoL. This lends additional support to the notion that personality factors might mediate perceived benefits from amplification in subtle ways.

Poster #: 58

Mobile-Assisted Word Recognition Tests Using Minimal Contrast Sets

Shrea Chari, BS, UC Los Angeles, San Diego, CA
Martin Hunt, BS, Open Speech Platform UC San Diego, San Diego, CA
Sarah Creel, PhD, UC San Diego, San Diego, CA
Harinath Garudadri, PhD, Qualcomm Institute, UC San Diego, San Diego, CA
Apurba Bose, SW Engineer, Qualcomm, La Jolla, CA

Objectives: The objective of this work is to develop an app for hearing competence tests using minimal contrast pairs. Open Speech Platform (OSP) is a suite of open source tools for clinical audiology research. It consists of a Real Time Master Hearing Aid (RT-MHA), Embedded Web Server, and a large, controlled set of minimally-differing test words. The app is written in Javascript, React Framework, Node.js, and Material-UI — these tools were chosen to facilitate rapid prototyping of audiology experiments using the "baseline app" as a template for customizing performance evaluation by developers with limited software experience. It is hypothesized that the flexible settings, stimuli presentation features, and results reporting of this app will allow for highly customizable experiments and additional outcomes assessment apps.

Design: The app consists of four sections: settings, stimulus, user input, and results compilation. The settings component, which researchers (and perhaps hearing aids users) interact with first, allows for the selection of various test parameters such as stimuli set, number of test questions, order of test questions (random or sequential), single or continuous presentation, and delay between successive stimuli. The range of settings allows for great customization of the app. Researchers can provide their own content files for the test and/or choose different sets for various experiments performed. The stimulus component involves the minimal contrast word sets that the user is presented with. Word sets were selected to contrast word-initial and word-final consonants known to be highly confusable in hearing impairment (examples, word-initial: hub, tub, pub, cub; word-final: lease, leaf, leash, leach). The audio of a given stimulus word is played and the user must select one of four answer options corresponding to the world played; this selection encompasses the user input section of the web demo. After completion of the test, the user is presented with their results: word-level accuracy, a table displaying answer choices, the user's answer, and the correct answer, and a confusion matrix displaying the user's phonetic level accuracy.

Results: Informal testing was conducted for functionality and correctness by undergraduate and graduate computer science students, which confirmed the operability of the app. Feedback is currently being collected from audiology researchers on approaches to running clinical experiments using this application. Assessments of the human computer interaction aspects of the web page will be gathered from web developers. Lastly, feasibility studies will be conducted with users with hearing impairments. Subjective evaluations of all users will be presented.

Conclusions: Preliminary feedback indicates that this app provides a missing link in the OSP tools. Researchers can change the HA fitting and measure speech recognition scores in a repeatable and reproducible manner due to the customizability of the settings. Tests can be performed in a variety of settings; speech can be directly played through the HA engine to the user or audio can be rendered by the web browser and played though the

speaker of the browser device. Feasibility studies can be conducted using users with and without hearing aids and in varied environments.

Poster #: 59

Hearing Aid Ownership by Race/Ethnicity, Socioeconomic Status among Medicare Beneficiaries

Julie Sunjoo Yi, BS, Johns Hopkins University School of Medicine, Baltimore, MD
Nicholas Reed, AuD, Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins University School of Medicine, Baltimore, MD
Amber Willink, PhD, Cochlear Center for Hearing and Public Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Hae Ra Han, The Johns Hopkins University School of Nursing, Baltimore, MD
Carrie Nieman, MD, Department of Otolaryngology-Head and Neck Surgery, Johns Hopkins University School of Medicine, Baltimore, MD

Objectives: Given the growing population of minority older adults in the US, understanding hearing aid ownership by race/ethnicity and socioeconomic status may have implications for tailoring hearing care to increase access among minority older adults. The objective of this study was to examine hearing aid ownership among community-dwelling older adults using a nationally representative sample of Medicare beneficiaries and to explore whether the associations differ by race/ethnicity and socioeconomic status.

Design: We used cross-sectional data from the 2017 Medicare Current Beneficiary Survey, a nationally representative survey of Medicare beneficiaries that includes information on demographics, health status, and healthcare utilization. In the 2017 cycle, 13,371 Medicare beneficiaries completed the survey, representing a weighted sample of 54.5 million beneficiaries. The analytic sample is 6,545 community-dwelling older adults with self-reported trouble hearing with or without hearing aid ownership, which represents approximately 25 million Medicare beneficiaries. Cross-sectional survey weights were applied to all analyses to account for the sampling design in the MCBS. Exposures included age, gender, self-identified race/ethnicity (white, Black, Hispanic, Asian American), income relative to federal poverty level (<100%, 100-149%, 150-199%, 200-399%, 400+%), education (less than high school, high school graduate, college graduate), rurality, insurance status. Multivariable-adjusted logistic regression was used to estimate the odds of hearing aid ownership.

Results: In the weighted sample, hearing aid ownership varied significantly by race/ethnicity among Medicare beneficiaries with self-report hearing difficulty (28% white, 19% Hispanic, 18.2% Asian, and 14.3% Black). Older adults with higher education had the highest prevalence of hearing aid ownership (30.2%), followed by high school graduates (25.6%), and less than high school education (19.5%). Similarly, beneficiaries with the largest income had a higher prevalence of hearing aid ownership, with 30.1% among those with an income 400+% above the federal poverty level versus 14.9% among those at<100%. Asian Americans had a low prevalence of hearing aid use despite higher levels of college education and income in comparison to other ethnic minority groups. After adjusting for age, gender, rurality, insurance status, and living arrangement, beneficiaries who identified as Black (OR=0.60, 95% CI: 0.43-0.82), Hispanic (OR=0.81, 95% CI: 0.67-0.99), and Asian American (OR=0.64, 95% CI: 0.42-0.97) had a lower odds of hearing aid ownership compared to white older adults. Lower odds of hearing aid ownership were observed with lower levels of income (<100% federal poverty level: OR=0.66, 95% CI: 0.54-0.82, as compared to 400+%) and less than high school education (OR=0.67, 95%CI: 0.57-0.77, as compared to college graduate).

Conclusions: In this nationally representative sample of community-dwelling Medicare beneficiaries, the prevalence of hearing aid ownership was lower among racial ethnic minorities and among beneficiaries with lower education and income. Furthermore, these findings provide some of the first nationally representative estimates of hearing aid ownership among older Asian Americans. Given the rapidly growing populations of ethnic minority older adults, including Asian Americans, further research is needed that includes diverse representation and more fully explores the unique barriers and facilitators of hearing care access and utilization within a cultural context.

Poster #: 60

Mobile-Assisted Frequency Warping for Improving Adaptive Feedback Cancellation

Yixing Wang, BS; Kuan-Lin Chen, PhD; Ching-Hua Lee, PhD; Deborah Forster, PhD; Wayne Phung, BS; Ankit Agarwal, MS; Harinath Garudadri, PhD, University of California San Diego, San Diego, CA

Objectives: Acoustic feedback due to acoustic coupling between the microphones and loudspeakers can cause the hearing aid system to become unstable. Freping (a portmanteau for Frequency Warping) is a novel approach that uses all-pass networks to perform nonlinear spectral mapping to improve Adaptive Feedback Cancellation (AFC). Previous works established that freping can bring speech quality improvements measured with objective metrics like the perceptual evaluation of speech quality (PESQ). Open Speech Platform (OSP) is a suite of open-source tools for clinical audiology research, comprising a Real Time Master Hearing Aid (RT-MHA) and an embedded web server. The objective of this work is to develop a web application as a part of OSP tool set that enables users to have a real-time control of freping parameters in order to evaluate the performance of freping on feedback control in the wild. The web app is written in JavaScript using React and Node.js framework, which is user-friendly and can be easily modularized and incorporated as a part of many potential hearing-aid management tools and experiments.

Design: The web application used for evaluation consists of a settings section, a stimulus file selector, and a user input section. The settings section allows users to (i) switch the running mode of RT-MHA in both the 6-band and 10-band configurations, (ii) to adjust the range of warping parameters for all frequency bands, and (iii) to change the output volume, and (iv) a stimulus file selector that allows for different audio files for testing. If the audio file includes transcription in the specified format, the user also has an option to toggle ON|OFF for display of live close captions. The user input section allows users to change the warping parameter for each frequency band, either through a slider or a text field. All changes of warping parameters are effective in real time (we define real time as under 1 ms) thus users can possibly perceive audio changes immediately. Given this interface, audiology researchers can iteratively select different stimulus files for testing, make adjustments for warping parameters to change frequency distortions in real time, and collect feedback from experiment subjects. The app can also serve as a module for sound frequency manipulations and be incorporated as a part of other web applications for investigations on the interplay of frequency warping and amplification settings in hearing aids.

Results: The functionality of the app has been tested informally by the software development team. Clinical experiments for subjective evaluations of freping using this app are being conducted by a team of audiology researchers. Based on informal subjective assessments, distortions due to freping are fairly benign. Additional objective and subjective evaluations will be presented.

Conclusions: Preliminary feedback indicates that this web app provides a missing link in the OSP tools for researchers to conduct live objective and subjective evaluations for frequency lowering in conjunction with

multi-band compression. The app runs on any device with a browser connected to OSP via hotspot, making it very convenient for researchers to run audiology investigations under different acoustic environments.

Poster #: 61

Preserving the Speech Amplitude Envelope: Effects of Different Compression Algorithms
Gregory Ellis, PhD; Pamela Souza, PhD, Northwestern University, Evanston, IL
Sébastien Santurette; Elaine Ng, PhD, Oticon A/S

Objectives: There has been considerable interest in customizing amplification strategies to specific auditory and/or cognitive ability of hearing aid wearers. In previous work, we quantified listeners' use of specific cues to speech, using a set of synthetic phonemes that varied in their spectral (formant) and temporal (envelope) properties. The degree to which individuals relied on different types of information to categorize the phonemes could be extracted by analyzing their responses. We demonstrated that listeners who predominantly used envelope information are more susceptible to distortion of the speech envelope. The data presented here are a first step in exploring best amplification strategies for such 'envelope-reliant' listeners, via an acoustic analysis of a commercial amplification strategy designed for envelope preservation.

Design: Test stimuli consisted of spondees in multitalker babble or speech-spectrum noise. An impulsive noise (e.g., a door slam, a car horn, etc.) occurred before the spondee in order to trigger the compressor. This impulsive noise occurred either 400 ms before the spondee (“no overlap” condition) or occurred 5 ms before the spondee (“overlap” condition). The speech-plus-noise signals were processed by four different compression simulations. Two algorithms represented conventional WDRC amplification, ranging from fast to slow. Two algorithms represented envelope-preserving amplification, with slow-acting, quasi-linear processing for stable input levels and fast-acting processing for rapidly changing input levels, using either a fixed or a variable number of channels for level estimation. Output signals were analyzed using metrics that quantified envelope fidelity, including the SII weighted Spectral Correlation Index (SCI) and Envelope Distortion Index (EDI).

Results: Results of the acoustic analysis show that the four types of algorithms have different effects on envelope fidelity. Fast WDRC resulted in the highest levels of envelope modulation, in both overlap and no overlap conditions. The envelope-preserving strategies resulted in highest envelope fidelity. Work is underway to relate the acoustic results to behavioral data.

Conclusions: Acoustic analyses show that the four compression algorithms distort the amplitude envelope of speech in different ways. Such differences are likely to impact perception among listeners who utilize envelope cues to different extents [Work supported by NIH]

Poster #: 62

T35 Student Poster Award

Compression Does Not Affect Spectral Weighting in Speech Recognition
John (Junseok) Shim, BA, Boys Town National Research Hospital, Mesa, AZ
Ryan McCreery, PhD; Adam Bosen, PhD, Boys Town National Research Hospital, Omaha, NE

Objectives: Spectral frequency bands vary in the amount of speech information they convey, with regions around 1 - 2 kHz conveying the most information and bands at the edges of the spectrum conveying the least. To maximize speech understanding for people who wear hearing aids, prescriptive formulae use frequency-importance weights to ensure frequencies which convey speech information are audible to listeners with hearing loss, but also compress the amplitude of auditory signals to minimize loudness discomfort. However, the effects of amplitude compression on frequency-importance remain unresolved. Previous studies have indicated that amplitude compression negatively affects speech intelligibility by diminishing the information available within a band. Here, we examined whether multiband compression altered the amount of speech information conveyed by each frequency band while keeping the audibility of each band constant. If multiband compression were found to alter the relative information carried across frequency bands then aspects of hearing aid fitting procedures would need to be revised to maximize speech intelligibility.

Design: Eighteen individuals with normal hearing who are native English speakers participated in this study. Band importance functions were measured for six adjacent one-octave wide frequency bands centered around octave frequencies from 250 Hz to 8 kHz. Multiband compression was applied to each frequency band such that the amplitude envelope was compressed toward the median level in each band, which preserved audibility. Speech recognition was tested for compression ratios of 1 (e.g. no compression), 3:1, and 6:1. We measured band importance by including either two or three bands for each stimulus. Target speech was 210 Consonant-Nucleus-Consonant words for each of the 6 conditions (3 compression ratios x 2 numbers of bands). Speech recognition was conducted remotely using a custom website and a video call with participants. Participants repeated each word out loud, and their responses were recorded and scored as correct or incorrect for each word.

Results: Increasing compression ratios reduced speech intelligibility. However, the importance of each frequency band remained constant across compression ratios, indicating that compression did not alter the importance of each frequency band. The 2 kHz band was more important when only two bands were included in each stimulus than when three bands were included, although the effects of compression were consistent across the two band and three band conditions.

Conclusions: For listeners with normal hearing at fixed compression ratios, greater amplitude compression reduced speech recognition but did not affect band importance. Listeners who use hearing aids often have compression ratios that vary across frequency bands, which may exert greater influence on cross-band speech cues than in the current study. Our result indicates that clinical hearing aid fitting procedures do not need to account for compression-related changes in frequency band importance, although there may be a need to examine cross-band speech cues in multiband compression.

PEDIATRIC AUDIOLOGY / OTOLOGY

Poster #: 63

Double-blind Randomized Clinical Trial of Children Learning to Use Hearing Aids

Hannah J. Stewart, PhD, University College London, London, UK
Joseph Pinkl, AuD, University of Cincinnati, Cincinnati, OH
Erin Cash; Lisa Hunter, AuD, PhD; David Moore, PhD, Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Objectives: Hearing aid acclimatization is a form of auditory learning that is likely to be most effective in younger listeners who experience prolonged associative pairing between meaningful stimuli (clear communicative speech) and rewards (ease of understanding). We assessed acclimatization in children aged 6-13 y.o. with mild-moderately severe hearing loss fitted with hearing aids using an adaptive processing algorithm, Open Sound Navigator (OSN) for up to 13 months. We hypothesized that extended use of OSN would result in improved performance on a range of speech-in-noise, language, academic and cognitive skills.

Design: After a complete audiological evaluation, forty-two children were recruited and assigned to age and hearing loss matched pairs. Each pair member was randomly assigned to use either OSN or a control, omnidirectional (omni), algorithm programmed into physically identical Oticon OPN hearing aids. All children completed a behavioural test battery within one week of receiving the study hearing aids (visit 1) and 6-13 months later (visit 2). The battery included measures of speech-in-noise, word and sentence repetition, non-word repetition, reading and math abilities and cognition (attention, memory and executive function). Children self-reported fatigue at v2 with the PROMIS questionnaire. At each visit caregivers completed questionnaires of speech and hearing abilities (SSQ, Glasgow Benefit Inventory). Between visits the children continued with their normal, everyday activities. The study was a registered (NCT03771287), double-blind randomized clinical trial.

Results: We found benefits of experience in both OSN and omni groups, but no significant difference in acclimatization between the groups in speech-in-noise, language, academic and cognitive measures. Across all children, we found strong correlations between hearing aid fit and improvements in executive function and attention over the study period. We found moderate correlations between hours of daily hearing aid use and improvements in speech-in-noise and attention abilities.

Conclusions: Acclimatization to OSN and omni algorithms were similar after up to 13 months of hearing aid use. Cognitive and speech-in-noise improvements were related to hours of daily hearing aid use and hearing aid fit.

Poster #: 64

Investigating Listening Difficulties in Children Using Chirp Speech EEG

Taylor Wicks, Clarkson University, Potsdam, NY
Chelsea Blankenship, Cincinnati Children's Hospital, Cincinnati, OH
Lee Miller, University of California - Davis, CA
David Moore, Cincinnati Children's Hospital, Cincinnati, OH
Lauren Petley, Clarkson University, Cincinnati Children's Hospital, Cincinnati, OH

Objectives: While the pathophysiology of developmental auditory processing disorder (APD) is presumed to involve deficit(s) of the central auditory nervous system (CANS), objective evidence supporting this assertion is lacking. Experimentally, some studies have used auditory brainstem responses (ABRs), middle-latency (MLRs), and long-latency auditory responses such as N1 and P2 to demonstrate differences between children with APD and their typically-developing peers along the CANS. Other evoked responses are also proposed to have diagnostic value. Problematically, the lengthy procedures involved in testing evoked responses at each level of the CANS make it impractical to adopt a test battery approach for this disorder. The goal of this project was to test the utility of a novel protocol known as Chirp Speech, which combines natural speech with synthetic chirps, to measure responses across the CANS in children with listening difficulties and their typically-developing peers.

Design: Thirteen children with listening difficulties (LiD; mean = 11.5 yrs, 11 male, 4 diagnosed with APD or an APD weakness), identified via the ECLiPS questionnaire, and 18 typically-developing controls (TD; mean = 11.6 yrs, 7 male) sat upright and listened to a 16-minute Chirp Speech story. Audio was presented diotically at 70 dB SPL via ER-2 inserts. While listening to the story, their electroencephalograms (EEG) were recorded via 52 active electrodes (50 scalp + 2 mastoid) and 3 passive electrodes (2 mastoid + 1 high forehead). To ensure attention towards the story, participants were asked to respond to a target word via button press.

Results: The TD group was disproportionately affected by postauricular muscle (PAM) artifacts, obscuring the ABR and MLRs in 12/18 TD children and 4/13 children with LiD. Furthermore, it was often difficult to identify Pb of the MLR, suggesting that the chirp rate of the Chirp Speech may have been too rapid to visualize these responses, which can be delayed in children. Nevertheless, group differences were found. High amplitudes for ABR wave V tended to occur in children with LiD ($p = 0.06$). In the LiD group, 6/9 children exhibited an amplitude in the upper 2 quartiles, while only 1/6 of TD children showed an amplitude in this range. Significant MLR latency differences (p< 0.05) were also observed, with TD children exhibiting earlier Pa and Nb waves (mean = 24 and 40.3 ms, respectively) than children with LiD (mean = 28.8 and 49.1 ms, respectively). No differences were observed in the long-latency auditory responses. Participants detected less than half of the target words. No difference in accuracy was observed between the groups ($p = 0.43$).

Conclusions: These results suggest that the Chirp Speech method is feasible in pediatric populations for the study of developmental APD. Frequent PAM artifacts and difficulty resolving the Pb suggest that methodological improvements should be implemented for future studies, including typical strategies for PAM reduction (e.g., a reclined seating position). Group differences at the level of the ABR and MLR suggest that Chirp Speech may be useful for investigating APD and should be explored with a larger sample of children.

Poster #: 65

Mentored Student Poster Award

Word Recognition in School-Age Children with Autism Spectrum Disorder
Danielle Bishop, BA; Mary Flaherty, PhD, University of Illinois at Urbana-Champaign, Champaign, IL

Objectives: This study evaluated the effects of autism spectrum disorder (ASD) on children's recognition of target words presented in the context of either noise or speech maskers. Impaired communication skills are a hallmark feature of ASD, and difficulties understanding speech in complex auditory environments are often reported. Despite the observed auditory processing deficits in individuals with high-functioning ASD, little attention has been given to behavioral studies examining speech-in-noise recognition in this population. The current study examined how children with ASD compared to their typically developing peers when recognizing words in the presence of competing speech or noise, and which acoustic cues in these contexts are most helpful for these individuals. Due to deficits in speech processing abilities and limitations in segregation and selective attention, we hypothesized that children with ASD would require a more advantageous signal-to-noise ratio than their typically developing peers to achieve the same level of performance across all conditions. Additional processing limitations were expected to differentially impact performance within each condition.

Design: Listeners were verbal high-functioning children with ASD (ages 6-13 years). Each child with ASD was individually age- and sex-matched with a child with typical development. An adaptive four-alternative, forced-choice disyllabic word identification task measured speech recognition thresholds in the presence of different competing maskers. The target stimuli were produced by a native English female talker. The four masker

conditions were: (1) Speech-shaped noise, (2) Amplitude-modulated noise (3) Two-talker female, and (4) Two-talker male. Condition 1 evaluated speech-in-noise recognition performance in the presence of a simple energetic masker, while Condition 2 examined the listener's ability to take advantage of temporal modulations. To assess informational masking effects, Condition 3 evaluated speech-in-speech recognition performance when the target and masker voices were of the same sex (both female), while Condition 4 evaluated speech-in-speech recognition would improve when the target and masker voices were of different sexes (female target, male masker).

Results: Preliminary data indicate that children with ASD have poorer speech recognition thresholds than age-matched controls, across all 4 conditions. Older children with ASD revealed larger differences across conditions than younger children, with similar performance for the 6-year-old matched participants. Children with ASD showed the best performance on the amplitude-modulated noise condition and the poorest performance on the two-talker female condition, similar to their typically developing peers.

Conclusions: These initial findings suggest that children with ASD may have increase susceptibility to masking relative to children who are typically developing. The pattern of the current results suggests that children with ASD struggle more when recognizing words in the presence of competing sounds, regardless of whether those sounds are noise or speech, with the difference between groups increasing beyond 6 years of age. Children with ASD were able to benefit from some of the same cues as their typically-developing peers, but to a lesser degree. Given that children with ASD likely encounter difficulties in hearing target speech in noisy environments throughout childhood, this could have potential implications for social interaction and communication throughout their life.

Poster #: 66

T35 Student Poster Award

Noise in Environments of Children with and without Hearing Loss

Jeffrey James Shymanski, BA, University of Iowa, Carroll, IA
Angela AuBuchon, PhD, Boys Town National Research Hospital, Omaha, NE

Objectives: Despite the disproportionate impact that noise has on children with hearing loss, little is known about the environmental noise these children encounter in their daily lives; existing research into environmental noise is limited by small sample sizes and a lack of typically-hearing comparisons. By retrospectively examining data collected as a part of the Outcomes of Children with Hearing Loss (OCHL) study, the current investigation aimed to 1) determine if children with hearing loss spend proportionally less time in noise compared to peers with typical hearing and/or are exposed to lower levels of noise, 2) evaluate impact of noise type, conversational context (i.e., noises taking place during conversation or pauses), and family factors on a child’s time spent in noise, and 3) compare levels of noise and meaningful speech across noise types and conversational context.

Design: OCHL environmental recordings sessions were obtained from 37 children with hearing loss and 9 children with typical hearing (ages 12-44 months). Families had been provided a LENA (Language Environment Analysis) recording device and were instructed to record all waking hours of their child’s day at monthly intervals. Between 1 and 10 recordings were collected per child, providing 270 recordings for analysis. Proportion of time spent in noise was calculated using the total durations of LENA-coded background noise classifiers (overlapping noise, nondescript noise, electronic noise, distant noise) relative to the total duration of

each recording. Sound pressure levels averaged over epochs of meaningful speech and noise were converted from dBFS to dB SPL. Family demographic information (maternal education, child age) was collected via parent questionnaire.

Results: Bayes factor linear models were constructed using participant- and recording-level intercepts as a null model, to which models containing predictors (e.g., hearing status, background noise type, conversational context, maternal education, child age) were compared. The evidence supported models in which the amount of time spent in noise and the average noise levels were the same within environments of children with hearing loss and their peers with typical hearing. Importantly, speech levels also did not differ between the two groups. Family factors did not predict noise time or levels for any noise type. Levels of nondescript noise varied by child age and were 1 dB greater during conversations than pauses.

Conclusions: No observed differences in noise level or time spent in noise between children with hearing loss and typically hearing peers suggests that families are equally (in)sensitive to noise despite supplementary training provided to families of children with hearing loss through early intervention services. Contrary to previous findings, background noise level was not related to socioeconomic status in the current investigation. LENA-classified variables (e.g., background noise type, conversational context) were highly predictive of time spent in noise. As there is little evidence validating the use of LENA software to identify background noise, further research may explore algorithms underlying noise classification. Nonetheless, algorithms were applied consistently across all children, and the Bayesian evidence overwhelmingly indicated that noise is not mitigated for children with hearing loss relative to typically hearing peers.

SPEECH PERCEPTION

Poster #: 67

Perception of Spectrally-Degraded, Foreign-Accented Speech
Jenna Barrett, Communication Sciences and Disorders, Ohio University, Athens, OH
Jing Yang, PhD, Communication Sciences and Disorders, University of Wisconsin - Milwaukee, Milwaukee, WI
Li Xu, PhD, Communication Sciences and Disorders, Ohio University, Athens, OH

Objectives: Both talker variability and spectral degradation introduce acoustic and phonetic deviations that have detrimental effects on speech recognition. This study investigated the perception of foreign-accented speech processed through noise vocoders in native English speakers (L1). It was predicted that L1 listeners' perception would perform more poorly with more heavily accented speech as well as vocoder processing. Additionally, listener's ability to use contextual information would interact with recognition of degraded, accented speech, resulting in poorer performance for sentences with less contextual information.

Design: Twenty native English listeners aged between 19 and 23 years old were recruited to listen to HINT and RSPIN sentence sets. The stimulus sentences were produced by four native Mandarin talkers who spoke English as a second language. The four non-native talkers (two males and two females) varied in accent severity (high or low), and the sentences were presented in the unprocessed condition and in a 6-channel vocoder-processed condition. The recognition performance was scored based on percent correct.

Results: The results showed that listeners performed poorer with the noise-vocoded speech than with the unprocessed speech. Additionally, the listeners showed greater difficulty in perception of more heavily accented speech than less heavily accented speech primarily in the vocoder-processed condition. The comparison of the

recognition performance between low- and high-predictability (LP and HP) RSPIN sentences revealed that the contextual information facilitated the recognition of foreign-accented speech in both unprocessed and vocoded conditions. Meanwhile, the listeners demonstrated less contextual benefit for the talkers with stronger accent in comparison to the listeners with less strong accent.

Conclusions: This study revealed that the interaction between accented speech and vocoder processing was detrimental to speech recognition in L1 listeners. Additionally, the RSPIN results suggested that listeners' ability to utilize semantic cues was modulated by the accent severity of talkers. These results provide evidence for the perceptual strategies of L1 listeners in response to spectrally-degraded, foreign-accented speech. This has implications for both the field of speech perception and our knowledge of cochlear implant users, as the signal processing in cochlear implants is similar to vocoder processing.

Poster #: 68

Effects of Transducer and Listening Condition on Speech Perception Performance

Lisa Lucks Mendel, PhD; Monique Pousson, MS; Kara Sander, BA; Bhanu Shukla, MA, University of Memphis, Memphis, TN

Objectives: Speech perception testing assesses how well listeners understand speech in a controlled environment and provides information regarding the fitting of amplification and planning rehabilitation. Such tests are typically administered monaurally in quiet to obtain ear-specific information regarding hearing sensitivity and speech comprehension. However, word recognition scores obtained in these conditions are often poor predictors of speech perception performance in natural listening situations. There is limited research investigating the ideal presentation mode of speech perception tests, such as which ear to test and the type of transducer that should be used. If the purpose of speech perception testing is to quantify one's functional hearing capabilities, research should investigate the impact of different ways to present speech stimuli and how this may affect one's speech perception abilities. The purpose of this study was to examine the influence of different transducers and listening conditions on speech perception performance. We hypothesized that individuals with normal hearing would perform well when listening to monosyllabic words in quiet and have more difficulty with words in noise, but would perform better when the stimuli were presented binaurally through headphones and in the sound field compared to monaural headphone presentation. The overall objective was to provide a strong rationale for implementation of specific testing parameters when assessing speech perception in clinical and research settings.

Design: A quasi-experimental comparative research design was used to assess word recognition performance for listeners with normal hearing to determine the effect of different transducers on speech perception performance. Twenty-two adults (M = 28 years of age) with normal cognitive function participated. A dichotic words and digits test was administered to determine ear dominance. CID W-22 monosyllabic word lists were presented in quiet and in noise under four conditions (right ear headphone, left ear headphone, both ears headphones, and both ears sound field).

Results: In quiet, scores were significantly better when the stimulus was presented to both ears (both headphones or sound field) than when presented to either the left or right headphone separately. In addition, no significant differences were found between the two binaural conditions (both headphones compared to sound field) or between the left and right ears. No significant difference was found for word recognition or SRT when comparing performance in the sound field to the left ear, but SRTs were found to be significantly better when comparing sound field performance to the right ear. Six of the participants showed a right ear dominance on the

dichotic tests. Preliminary analysis of performance in noise revealed no significant differences across conditions.

Conclusions: As expected, speech perception performance was better in binaural compared to monaural conditions, but there was no measurable difference between binaural headphones and sound field presentation. Additional analyses are being conducted to further determine the influence of ear dominance and the use of noise. These data suggest that speech perception testing performed binaurally (either under headphones or in the sound field) yields better results than testing ears individually under headphones.

Poster #: 69

Speech Intelligibility at Realistically Effortful Listening Situations

Petri Korhonen, MS, Widex ORCA-US, WS Audiology, Lisle, IL

Objectives: A common outcome index of speech-in-noise testing, the speech reception threshold corresponding to 50% intelligibility (SRT50), may be useful in characterizing an individual listener and for showing the effect of hearing aid processing. However, performance at 50% intelligibility may not reflect the degree of listening difficulty in functionally meaningful listening situations. Subjective listening effort rating for a given listening condition may provide insight on how likely the listener is willing to stay in such listening situation. The current study investigated the relationship between the subjective listening effort and speech recognition performance to inform us which speech reception threshold criteria would correspond to listening situations that are rated realistically effortful.

Design: Repeat-and-recall (RRT) test was used to assess speech recognition performance and subjective listening effort. Listeners rated how effortful they found the listening situation on a 10-point rating scale, with "1" representing minimal effort, "5" representing moderate effort, and "10" representing very effortful listening. RRT performance was measured with 41 normal hearing and 78 aided hearing impaired listeners in total of 3084 trials. Speech was presented from 0° at 68 dB SPL in quiet and in the presence of background noise presented at 0, 5, 10, and 15 dB SNR.

Results: Both normal hearing and hearing-impaired listeners made relatively uniform use of the listening effort scale across tested SNRs. When speech recognition performance was 50% correct or below, both NH and HI listeners reported listening effort to be very effortful (rating > 8). Individual listening effort ratings were variable when intelligibility was above 75%. The average effort rating was "moderate" (rating = 6) at 85-90% intelligibility for both NH and HI listeners.

Conclusions: Evaluation of speech-in-noise performance at SNR corresponding 50% performance reflects a listening situation that listeners found very effortful. Such listening scenarios may not occur frequently in daily speech communication, as listeners may avoid staying in such situations for prolonged periods of time. If clinician is looking to evaluate the likelihood of success in daily speech communication, an evaluation of SRT at a higher criterion, say 85% correct, may be more appropriate than a criterion of 50%. Such changes in convergence criterion in adaptive speech-in-noise testing can be achieved via algorithmic modifications.

Poster #: 70

Benefit of Remote Microphone in Speech in Noise with Masked Talker

David Leary Taylor, AuD, Phonak, Dekalb, IL

Objectives: The purpose of this study was to investigate how the loss of high frequency information caused by a face mask affects the benefit of using a Roger microphone for individuals with moderate to severe hearing loss. The authors hypothesized that Roger benefit will not be impacted by the talker's use of a face mask.

Design: Seventeen adult participants with moderate to severe hearing loss were recruited. Each participant was seen for one appointment lasting approximately two hours. Each individual was fit bilaterally with Audéo™ P90 devices. An acoustic scene was designed to surround the participants in diffuse cafeteria noise at 70 dBA. The background noise was generated by four loudspeakers, one in each corner of the room. The participant was seated in this loudspeaker array, and KEMAR (with mouth simulator) was placed six ft. (approximately two meters) away from the participant at zero degrees azimuth, facing the listener. KEMAR was equipped with the Roger Touchscreen Mic, placed 20 cm below the loudspeaker in lapel mode. The American English Matrix test was used to assess speech perception in noise. Testing was preceded by one familiarization run, and the test was performed twice for each of the following conditions:1.No mask / no Roger2.No mask / with Roger3.Cloth mask / no Roger4.Cloth mask / with Roger5.ClearMask™ / no Roger6.ClearMask™/ with RogerThe score from each trial was averaged, such that each participant had a single score for each of the six experimental conditions. Test lists were randomized, and conditions were counterbalanced for both mask type and Roger condition. The American English Matrix test was set to adapt the level of the speech stimuli in constant 70 dB(A) cafeteria noise to find the SNR at which participants achieved 50% of all words correct (SNR50).

Results: To understand the benefit of Roger with masked talkers, an LME model was constructed with a dependent variable of SNR50, fixed effects of mask type and presence/absence of Roger (with an interaction term), and random effect of participant. Model results indicate a marginally significant degradation of performance with the cloth mask (_ = 0.981, 95% CI = [0.053, 1.909], p = 0.046), but no significant impact of the ClearMask. Roger use resulted in a substantial, statistically significant improvement (_ = -20.172, 95% CI = [-21.01, -19.243], p< 0.001). There were no significant interactions between Roger use and either type of mask. These results suggest that cloth face masks have a deleterious impact on speech perception (even without accounting for lost visual cues), and Roger benefit is neither heightened nor degraded by the use of a face mask.

Conclusions: This study has shown equivalent benefit of Roger in instances where talkers are wearing masks, relative to situations in which talkers are not wearing a mask. Thus, it is reasonable to assume that Roger is a viable option for typical use-case situations, despite the current challenges of communicating with people using face masks.

Poster #: 71

Real-time Computation of a Ratio Mask for Speech Enhancement

Marcos Antonio Cantu, PhD, University of Oldenburg, Oldenburg
H. Steven Colburn, PhD, Boston University, Boston, MA
Volker Hohmann, PhD, University of Oldenburg

Objectives: Interfering speech has rapid spectrotemporal fluctuations that noise reduction algorithms have difficulty suppressing without a concomitant loss, or distortion, of binaural cues for spatial hearing. Stationary noise has a spectrum that does not change over time, whereas interfering speech, with its spectrotemporal fluctuations, is an example of non-stationary noise. This study describes and evaluates Short-Time Target Cancellation (STTC), which computes a ratio mask (i.e., a time-varying filter), for attenuation of both stationary

and non-stationary noise sources (e.g., interfering talkers), with preservation of binaural cues for spatial hearing, using computationally efficient processing that can be implemented on Assistive Listening Devices (ALD) with low requirements in terms of memory size and computational power.

Design: The STTC processing is evaluated here using virtual room acoustics, a spherical head model, and computational measures of sound source segregation and speech intelligibility. Furthermore, the evaluation is carried out using short-time analysis windows of only 4 ms duration, so that the overall processing latency will be below 10 ms, an acceptable latency for an ALD. Throughout, the STTC processing is both compared with, and combined with, the output of a Generalized Sidelobe Canceller (GSC) adaptive beamformer, as the STTC's ratio mask can be used as a postfilter for adaptive beamforming techniques.

Results: The results demonstrate that the STTC processing outperforms the GSC beamformer in the Source-to-Interferers (SIR) and Source-to-Distortions (SDR) measures of sound source segregation, as well as in the Modified Binaural Short-Time Objective Intelligibility (MBSTOI) measure of speech intelligibility. However, the combination of STTC and GSC processing, wherein the STTC's ratio mask is used as a post-filter for the GSC adaptive beamformer, posted higher performance numbers than either processing scheme alone.

Conclusions: An advantage of the STTC processing, relative to adaptive beamforming techniques, which generally have diotic (i.e., mono) outputs, is that the ratio mask (i.e., time-varying filter) computed by the STTC processing is a set of frequency channel weights (k), for every short-time analysis frame (n), that can be applied independently to signals at the Left and Right ear, thereby enhancing speech intelligibility for a target talker while still preserving binaural cues for spatial hearing. When using the STTC time-frequency mask as a post-filter for fixed and/or adaptive beamforming, any benefit measured in objective measures of performance (e.g., noise reduction, speech intelligibility, speech quality) may be offset by the loss of binaural cues for spatial hearing, which are important for maintaining a sense of spatial and situational awareness. Future work will involve evaluating prototype STTC assistive listening devices, with real-time signal processing implemented using the open Master Hearing Aid (openMHA), in psychoacoustic tasks with human listeners.

Poster #: 72

Neural Encoding of Speech Sound Features at Birth

Sonia Arenillas-Alcón, MS; Jordi Costa-Faidella, PhD; Teresa Ribas-Prats, MS, Brainlab - Cognitive Neuroscience Research Group. Institute of Neurosciences, Department of Clinical Psychology and Psychobiology, University of Barcelona (Catalonia, Spain), Barcelona, Spain
María Dolores Gómez-Roig, MD, PhD, BCNatal-Barcelona Center for Maternal Fetal and Neonatal Medicine, Institut de Recerca Sant Joan de Déu, Hospital Sant Joan de Déu, Esplugues de Llobregat (Catalonia, Spain), Barcelona, Spain
Carles Escera, PhD, Brainlab - Cognitive Neuroscience Research Group. Institute of Neurosciences, Department of Clinical Psychology and Psychobiology, University of Barcelona (Catalonia, Spain), Barcelona, Spain

Objectives: Neural encoding of voice pitch and formant structure play a crucial role in speech recognition. However, the extent to what newborns are capable of extracting this information remains unclear. Our aim was to characterize the functional maturity of voice pitch and formant structure encoding mechanisms at birth with non-invasive electrophysiological recordings, using the adult population as a reference, by developing a new speech sound stimulus that is optimally designed to allow the simultaneous assessment of both components in a relatively short period of time.

Design: The frequency-following response (FFR), a non-invasive electrophysiological correlate of early auditory processing that enables the characterization of voice pitch and formant structure encoding accuracy, was recorded in a sample of 34 healthy term newborns, without obstetric pathologies or risk factors related to hearing impairments, and 18 young adults, with no self-reported history of neurological, psychiatric or hearing impairment, recruited from Sant Joan de Déu Hospital (Barcelona, Spain) and University of Barcelona (Spain), respectively. FFRs were recorded to 4000 presentations (alternating polarities) of a single two-vowel (/oa/) 250 ms-long stimulus, with a rising-pitch-ending (F0=113 Hz from 0 to 160 ms, then rising up to 152 Hz; /o/ section from 10-80 ms, F1=452 Hz, F2=791 Hz; /a/ section from 90-250 ms, F1=678 Hz, F2=1017 Hz). FFRs elicited to both stimulus polarities were averaged (FFRenv) to accentuate F0 encoding, which was analyzed separately for /a/ steady (90-160 ms) and /a/ rising (160-250 ms) sections (spectral SNR and pitch measures extracted from the autocorrelation). Subtracting the FFR elicited to both stimulus polarities (FFRtfs) the encoding of the harmonic structure was emphasized, and the corresponding spectral peaks (SNR) of the formants during the /o/ (10-80 ms) and /a/ (90-160 ms) vowel sections were analyzed separately.

Results: FFRenv analyses showed comparable F0 encoding in newborns and adults: no group differences in F0 spectral amplitude signal-to-noise ratio (SNR) and pitch strength values during the /a/ steady and the /a/ rising sections. Likewise, both groups showed decreased F0 values during the rising section than the steady section. In contrast, FFRtfs analyses yielded significant group differences in formant structure encoding. Adults exhibited larger SNRs than newborns both at lower and higher formant frequencies, and showed larger SNRs to the first formant frequency of the presented vowel: at 452 Hz (/o/¬¥s F1) during the /o/ section, and at 678 Hz (/a/¬¥s F1) during the /a/. Likewise, newborns exhibited a significantly larger SNR to the /o/'s F1 during the /o/ section as well, but presented a barely measurable signal at 678 Hz.

Conclusions: Our work provides the first evidence that neonates, in addition to their known ability to accurately encode changes in voice pitch, are also able to encode the formant structure of vocalic sounds at spectral components below ca. 500Hz, coinciding with the low-pass filter characteristics of the womb as reported in the literature. Therefore, while voice pitch encoding appears adult-like at birth, formant structure representation is maturing in a frequency-dependent manner. Furthermore, we demonstrate the feasibility to assess both components of the speech signal within clinical evaluation times (30 min) in a hospital setting, and suggest the possibility to use this new stimulus as a tool to perform a longitudinal assessment of speech encoding in babies from their first hours of life throughout their first years.

Poster #: 73

Extended High-Frequency Pure-Tone Thresholds Predict Realistic Speech-in-Speech Recognition
Brian B. Monson, PhD, University of Illinois at Urbana-Champaign, Champaign, IL
Emily Buss, PhD, University of North Carolina, Chapel Hill, Chapel Hill, NC

Objectives: The standard clinical audiogram typically does not include testing at extended high frequencies (EHFs; >8 kHz). It has been reported that EHFs predict some measures of speech perception, including speech recognition in noise, however there are mixed findings on this topic. These mixed findings may be due, in part, to variability in methods used previously, including stimulus type, bandwidth, and presentation method. The goal of the present research was to assess the relationship between EHF pure-tone thresholds and speech-in-speech recognition using stimuli that reflect real-world acoustics of speech-in-speech listening.

Design: Data from two studies measuring masked speech reception thresholds (SRTs) will be presented. In both studies, target and masker speech consisted of high-fidelity speech recorded with a 44.1-kHz sampling rate using a microphone with a flat frequency response out to 20 kHz. Speech was recorded at on- and off-axis microphone locations to simulate talkers having rotated head orientations relative to the listener (e.g., not directly facing the listener), as would be expected in a real-world "cocktail party" environment. Maskers had either 0-, 45-, or 60-degree head orientations, while the target talker always had a 0-degree head orientation. Maskers were presented either co-located with or spatially separated from the target talker. One study evaluated performance for normal-hearing listeners (N=34) with a broad age range and a broad range of normal and elevated EHF thresholds. The other study tested only young listeners (N=41) with normal hearing at both standard audiometric frequencies and EHFs.

Results: Better EHF thresholds were significantly associated with better SRTs when maskers had 45- or 60-degree head orientations. This was true even for the young listener group with normal EHF thresholds. EHF thresholds did not predict SRTs when maskers had 0-degree head orientations. Pure-tone thresholds at standard audiometric frequencies did not predict SRTs.

Conclusions: EHF pure-tone thresholds may account for some of the variability in speech-in-noise performance often observed with listeners that have clinically normal audiograms. Proper assessment of this relationship requires test conditions that reflect real-world listening environments. Incorporating high-fidelity speech recordings and effects of talker head orientations in the clinic and the laboratory may improve the precision of speech-in-noise tests.

Poster #: 74

Comparison of Automated Audio-Visual Speech Recognition to Audio-Only Speech Recognition
Arun Manakal Raghavan, BS, University of Cincinnati College of Medicine, Cincinnati, OH
Gavriel Kohlberg, MD, University of Washington Department of Otolaryngology - Head and Neck Surgery, Seattle, WA

Objectives: Individuals naturally integrate auditory and visual cues in order to improve speech perception. Automated speech recognition programs that can function accurately in background noise may be able to aid individuals better communicate in adverse listening conditions. We hypothesize that an audio-visual speech recognition program (AVSRP) that not only analyzes the acoustic speech signal but also facial articulatory motion captured via video camera will outperform a commercially available auditory only speech recognition program (Google Speech-to-Text) in background noise.

Design: A neural-network based audio-visual speech recognition program (AVSRP) was trained on both audio and video data from a subset of the Oxford-British Broadcasting Corporation (BBC) Lip Reading Sentences 2 (LRS2) dataset, which consists of 96318 video excerpts of spoken sentences from BBC television. Each excerpt consists of a single English sentence of up to 100 characters in length, recorded at 25 frames per second. Each excerpt is cropped to a 112 by 112 pixel region around the mouth. The AVSRP machine learning algorithm was implemented as a series of multi-head self-attention feed-forward network layers. The algorithm uses connectionist-temporal-classification (CTC) scoring in order to adjust for alignment of the phonemes within an individual sample. A test set from the LRS2 dataset of 1243 audio-visual speech excerpts, which was not part of the training set for the AVSRP, were modified with the addition of multi-talker babble noise at defined signal-to-noise ratios (SNR) of -20, -10, -5, and 0 decibels (dB). The test set was transcribed in its original form without background noise as well as at each SNR level by both the AVSRP and the commercial auditory only

speech recognition program. Performance was recorded as the percent of correct words transcribed. Chi-square analysis was performed for statistical significance.

Results: In the absence of background noise, no significant difference was found between the performance of the AVSRP and the commercial auditory system. In the lowest noise condition (SNR: -20 dB), the commercial system achieved an accuracy of 93.9%, while the AVSRP achieved an accuracy of 93.2% ($p = 0.46$). At an SNR of -10 dB, the commercial system achieved an accuracy of 75.5% while the AVSRP achieved an accuracy of 90.4% ($p< 0.001$). At an SNR of -5 dB, the commercial system achieved an accuracy of 15.4% while the AVSRP achieved an accuracy of 84.2% ($p< 0.001$). At an SNR of 0 dB, the commercial system achieved an accuracy of 4.4% while the AVSRP achieved an accuracy of 62.9% ($p< 0.001$). Across all noise conditions, the commercial speech recognition program achieved an average accuracy of 48.3% and the AVSRP achieved an accuracy of 86.6% ($p< 0.001$).

Conclusions: In low noise conditions ($\leq$ -20 dB SNR) there was not a significant difference in accuracy between the AVSRP and the commercial program. In high background noise conditions (-10 dB to 0 dB SNR), a speech recognition program that makes use of both auditory and visual input was able to outperform a commercially available speech recognition system that uses only auditory input.

Poster #: 75

Statistical Word Learning: Elementary Children with Listening or Hearing Impairment

Hannah J. Stewart, PhD, University College London, London, UK
Erin Cash, Cincinnati Children's Hospital Medical Center, Cincinnati, OH
Joseph Pinkl, AuD; Jennifer Vannest, PhD, University of Cincinnati, Cincinnati, OH
David Moore, PhD, Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Objectives: Statistical learning (SL), the extraction of regularities, has been hypothesized to underlie language acquisition in children. However, how SL occurs in children with hearing impairment is unclear. As a primary aim, we explored the ability of children aged 6 to 17 y.o. to learn an artificial grammar. We assessed children with 1) normal hearing and normal listening ability (TD, n = 54), 2) normal hearing but everyday listening difficulties (LiD, n = 30), and 3) children with mild to moderately-severe hearing loss (MMHL, n = 11). As a secondary aim, we assessed the ability of children with MMHL to learn an artificial grammar in the presence of a background noise (n = 12).

Design: Participants were exposed to an aX and Yb grammar with the a and b components consisting of a single syllable nonword (CV) and the X representing one-syllable nonwords (CVC) and Y representing one-syllable nonwords (CVCCV). Words included 'poe zek' and 'poe zug' (aX) along with 'wagso koo' and 'zikvoe koo' (Yb). To keep the task entertaining, the children were exposed to the grammar in the form of a game where they were teaching an alien a new language. Each child had a single exposure to the grammar and was assessed throughout the game.

Results: The ability to learn the grammar significantly improved with age across all participants and the children became significantly faster with age. TD children (M = 67.6%, SD = 14.3%) performed significantly better ($p = .005$) than children with LiD (M = 57.0%, SD = 9.0%). TD children (M = 2.7s, SD = 0.5s) were also significantly faster at responding than the other groups (LiD $p = 0.04$, M = 3.4s, SD = 1.1s; MMHL $p = 0.02$, M = 3.4s, SD = 0.8s). We found no group differences in the error types during the task (i.e., mixing the grammars

(aY and Xb) or linear errors (Xa instead of aX)). We found no significant change in grammar learning when presented to children with MMHL in background noise.

Conclusions: TD children and children with listening or hearing impairment are able to learn a novel artificial grammar. While children with MMHL performed similarly to TD children, children with LiD had lower accuracy and reaction times than the TD children. Learning the artificial grammar in background noise did not affect the abilities of the children with MMHL. The poorer performance of children with LiD is consistent with other work in our lab showing that these same children had predominantly language and other cognitive deficits underlying their LiD rather than sub-clinical hearing loss. Conversely, the normal performance of children with MMHL suggested they did not have language deficits, at least of a type needed to perform the SL task.

Poster #: 76

Relationship between EMA and Standard Questionnaire in Evaluating Speech Understanding

Jingjing Xu, PhD, Starkey Hearing Technologies, Eden Prairie, MN
Yu-Hsiang Wu, MD, PhD; Elizabeth Stangl, AuD, University of Iowa, Iowa City, IA
Shareka Pentony, MS, Starkey Hearing Technologies (current affiliation: Alameda and Contra County Health Centers, CA)
Jason Galster, PhD, Starkey Hearing Technologies (current affiliation: Advanced Bionics, Valencia, CA)

Objectives: Real-world hearing aid outcomes are commonly measured using standard questionnaires at the end of the trial, providing a comprehensive measure of different outcomes. Ecological momentary assessment (EMA) is another method that allows measuring outcomes in the field multiple times a day throughout the trial using repetitive surveys. Responses to EMA surveys reflect the listener's experience in real-time and in-situ, whereas responses to a questionnaire at the end of the trial require the listener to recall and summarize his/her experience across the trial. Given that both methods are valid measures of outcomes in the field, the utility in comparing the two methods on the same outcome domain appears to hold significant value. In addition, because of the retrospective manner of standard questionnaires, how listeners recall and summarize their experience could be impacted by a recency effect (the tendency to remember the most recent experience best) is still unclear. Therefore, the purpose of this study was twofold: (1) to demonstrate the relationship between assessing real-world aided speech understanding performance with one question in an EMA survey and with the speech subscale of the Speech, Spatial and Qualities of Hearing Scale (SSQ), and (2) to assess whether the strength of this correlation increases toward the end of the trial.

Design: Participants were 25 experienced hearing aid users. The participants completed EMA surveys on smartphones to report every 45 mins for a 1-week trial. At the end of the trial, each participant filled out the SSQ.

Results: In total, the participants completed 2711 EMA surveys. Ratings for the EMA survey question that assessed speech understanding performance were used for data analysis (question: “I could follow the conversation/speech”; five responses: from “Strongly agree” to “Strongly disagree”). The speech understanding ratings were first averaged for each participant across the trial. The mean EMA ratings and the SSQ-Speech scores were moderately correlated (Spearman’s rho=0.45). In order to explore whether there was a recency effect (stronger correlations between SSQ-Speech scores and EMA rating towards the end of the trial), within each day of the trial, the EMA speech understanding ratings were averaged for each participant and the correlations between EMA and SSQ were examined day by day. The strength of the correlation ranged from

weak to moderate (Spearman's rho between 0.07 and 0.47) with stronger correlation on Days 4 and 5 of the trial.

Conclusions: The weak to moderate association between EMA and a retrospective questionnaire in measuring aided speech understanding suggests that these two measures assess similar but different aspects of outcomes in the field. The day-by-day correlations did not show a clear trend for recency effect.

Poster #: 77

Voice-tone Recognition Amid Conflicting Information and Executive-function Demands

Blas Espinoza-Varas, PhD, Communication Sciences and Disorders, University of Oklahoma Health Sciences Center, Oklahoma City, OK

Objectives: In conditions imposing substantial cognitive conflict (e.g., multitasking), accurate speech recognition can be challenging; understanding this challenge was the aim of this project. Current models assume that speech recognition depends both on sensory and cognitive processing, and since information-processing capacity is finite, at any moment only a limited amount of information can be attended to, maintained active in memory, and used effectively. Thus, if conflicting information draws heavily on the pool of cognitive resources, much fewer will be left to process speech information, and recognition accuracy will degrade.

Design: We measured the accuracy and speed of voice-tone recognition in the absence (i.e., no conflict, NC) and amid information and response conflict that placed demands on inhibitory control, selective attention, or cognitive flexibility. In the experimental task, the left- or right-ear headphone presented the flanker word "Left" or "Right" followed by an impeding (e.g., "Stop") or an instigating verbal directive (e.g., "Go") spoken in stern or lenient tone (e.g., Left Stop!). Participants were asked to ignore the flanker and the ear side, attend to the directive voice tone and decide if it was lenient or stern by pressing response keys. "Stern" or "lenient" mapped onto a "left" or "right" response for impeding directives, and the reverse for instigating directives. On each trial, the flanker and ear side could be incongruent (in conflict), or congruent (no conflict) with the correct response side. These laterality-conflict (LC) paradigms assessed effects of selective attention and inhibitory control for potent responses prompted by laterality cues, which could be in conflict with the voluntary responses-to-voice-tone mapping. In addition to LC, a set-switching (SS) paradigm presented both impeding and instigating directives within each trial block, and being correct required adhering to the respective voice-tone to response side mapping. Across trials, participants had to switch mapping rules depending on whether the directive was impeding or instigating, which required cognitive flexibility. Participants (n=17) were teenagers or young adults (16-22 years old), native American-English speakers, with normal hearing.

Results: Without conflict (NC), voice-tone recognition errors were negligible, but increased significantly with LC and SS conflict, being largest with the latter; these trends were observed both with impeding and instigating directives, but percent errors were larger with the latter. Relative to NC, with both impeding and instigating directives response latency increased significantly with SS but not with LC conflict. Across directive sets, with LC conflict, responses were slightly slower for instigating than for impeding directives.

Conclusions: Large and significant increases in voice-tone recognition errors were observed amid conflicting information that engages executive functions; the effect was largest amid SS conflict that required cognitive flexibility. These effects are consistent across impeding and instigating directives, and increase in size in accordance with the cognitive load; significant increases in voice-tone recognition latency were observed only

with SS conflict. Clearly, engaging executive functions interferes with recognition of the voice tone of verbal directives. The results are consistent with models proposing that speech recognition depends both on sensory and cognitive processing, and that cognitive-processing capacity is limited.

Poster #: 78

Aging and Cognition modulate Talker Familiarity Benefit in Noise

Julie Cohen, AuD, PhD; Sandra Gordon-Salant, PhD, University of Maryland, College Park MD, College, MD
Douglas Brungart, PhD, Walter Reed National Military Medical Center, Bethesda, MD

Objectives: In complex auditory environments, speech understanding is affected by both auditory and cognitive factors. Factors such as aging and working memory are significantly correlated with a listener's speech understanding performance in noise backgrounds. Working memory is a limited capacity system that allows for the storage and manipulation of information in short term memory. When bottom-up constraints such as signal degradation, or the top-down process of reduced working memory capacity are present, speech recognition performance may be reduced more for older than younger adults. The familiarity of a talker or masker voice has been shown to improve a listener's speech understanding performance in noise. The objective of this study was to measure the extent to which a familiar voice reduces the demand on available cognitive resources as measured by a test of increased auditory working memory load for younger (YNH) and older (ONH) normal-hearing adults. The working hypothesis is that listeners will perform better on a 1-back test (e.g., high memory load) when the target talker is a familiar voice compared to an unfamiliar voice, reflecting reduced demand on cognitive resources with the familiar voice.

Design: Pairs of normal hearing adults who were highly familiar with each other were recruited. A total of 15 YNH and 15 ONH normal hearing adults completed this study. Couples recorded sentences from the Boston University Gerald (BUG) corpus and completed a battery of cognitive tests that included the LSPAN and Flanker tests. An adaptive tracking procedure was used to measure speech reception threshold for 80% speech intelligibility (SRT80) on an immediate sentence recall task when the familiar voice was the target or the masker and in the presence of either a single competing talker or speech shaped noise (SSN). The target sentence was fixed at 65 dB SPL and the masker was adjusted adaptively in level across 20 trials. The 1-back trials required the participant to recall a sentence presented immediately before the most recently presented sentence. The 1-back trials were tested at each individual listener's sequence of signal-to-noise ratios (SNRs) that produced a mean score of 80% speech intelligibility (SRT80).

Results: Across the YNH and ONH listeners, performance on the 1-back test was influenced by listener age group, competing signal condition, and performance on the cognitive measures (Flanker and LSPAN tests). ONH listeners with higher working memory capacity exhibited a benefit on 1-back performance when listening to a familiar vs. unfamiliar target voice.

Conclusions: These findings suggest that listening to a familiar voice can improve speech understanding in noise when the background masker is composed of speech, and that ONH listeners can take advantage of the talker familiarity benefit to improve performance on a test that increases demands on working memory.

Poster #: 79

Mentored Student Poster Award

Speech Perception Performance in Ecological Noise
Bhanu Shukla, MA; Lisa Mendel, PhD, Memphis, TN

Objectives: Since its inception, speech perception testing has been an important part of the audiology test battery. There are several types and forms of speech in noise tests which are currently being used to measure speech perception ability. Some of these tests are the Connected Speech Test, the Hearing in Noise Test, the Words in Noise Test, the Quick Speech in Noise Test, the Bamford-Kowal-Bench Speech in Noise Test, the Listening in Spatialized Noise-Sentences Test, and the AzBio Sentences. While these tests provide a good estimate of speech in noise performance, results are far from being realistic. The noise used in these tests does not represent a natural listening environment. It is important to have an efficacious speech perception assessment that assesses the actual performance of the listener in the real world. Creating such an assessment tool is needed to accurately reflect performance. The purpose of this study was to develop and validate an ecological noise that can simulate a realistic environment for speech perception testing.

Design: The study design was a non-experimental comparative research design, and it was divided into two phases. In the first phase, a unique ecological noise was generated using different environmental sounds either downloaded from the internet or recorded. Four-talker babble was added to the ecological noise, and a 2-minute, 20-second .wav file was created. In the second phase, speech perception performance was measured and compared using this ecological noise and other noises (12-talker babble, 4-talker babble, and speech spectrum noise, SSN) at different signal-to-noise ratios (SNRs) of 0 and +5 dB. The sentences from the AzBio, QuickSIN, and HINT tests were used with their respective noises and with the ecological noise. A total of 27 individuals (aged 18 to 40 years; M = 25.5) from the University of Memphis and the city of Memphis participated in the study.

Results: Speech perception performance was poorer when ecological noise was used compared to all other noises. The noise conditions resulting in the worst performance beyond the ecological noise were 4-talker babble, 12-talker babble, and SSN, respectively. Also, speech perception scores for 0 dB SNR were significantly poorer compared to +5 dB SNR for all the noises. The combination of both Informational Masking and Energetic Masking effects in our ecological noise makes it more realistic. This leads to an even greater decrease in the intelligibility of the target sentences.

Conclusions: Ecological noise presents a more challenging listening situation than the use of multi-talker babble or speech shaped noise. The ecological noise developed in this study could be useful in the basic audiological battery for speech perception testing. We believe that the speech perception scores measured using this ecological noise can provide a more realistic estimation about communication in the natural environment than multi-talker babble or speech shaped noise and would be helpful for counseling people with hearing impairment.

Poster #: 80

T35 Student Poster Award

Visual Cues to Perception of Intonation
Alyssa Louise Wciorka, BS, Washington University in St. Louis School of Medicine, St. Louis, MS
Kaylah Lalonde, PhD; Monita Chatterjee, PhD, Boys Town National Research Hospital, Omaha, NE

Objectives: A number of acoustic cues allow listeners to differentiate between questions and statements, including pitch and intensity contours. Talkers also produce visual cues that differentiate between statements and questions. Greater displacement and velocity of head and eyebrow movement are produced for questions than for statements. Studies have shown that people can distinguish between questions and statements from visual cues, but the literature lacks an understanding of which visual cues contribute to intonation perception, how much these vary across talkers, and how much these change based on speaking style (e.g., speaking to children vs. to adults). The purpose of the present study was to address these gaps in our knowledge by examining production (Exp. 1) and perception (Exp. 2) of visual cues to intonation. We hypothesized that talkers have more facial movement when producing questions than statements and when speaking to a child than to an adult. We also hypothesized that perceivers can more easily differentiate between questions and statements in the child directed speaking style than the adult directed speaking style.

Design: Exp. 1 quantified talker's head and eyebrow movements during production of questions and statements, and examined how movement varies across talkers and speaking styles (adult or child directed speech). Six talkers who were blind to the purpose of the study were video and audio recorded saying spondees with these parameters. Specialized software was used to track relevant points on the face to analyze eyebrow, eye, and face movement.Exp. 2 examined how well adults could identify question and statement based on visual cues from the top half of each talker's face. Videos were stripped of audio and the bottom half of the face was covered to remove auditory cues and lipreading cues, respectively. Participants were 30 adults who reported normal or corrected-to-normal vision, no hearing difficulties, and English as their primary language. Participants viewed each video, then indicated whether the talker was asking a question or making a statement. The study had a within-subjects design. Catch trials were included to ensure participants were attentive.

Results: Preliminary analyses suggest a greater range of rigid head motion and brow height for child-directed speech than adult-directed speech. Inter-talker variability was observed in both production and perception data. Listeners were worse at perceiving question/statement differences when presented with talkers with less head and brow movement. Analyses are ongoing and will include determining which production cues best predict perception of visual intonation.

Conclusions: Head and eyebrow movement can differentiate between statements and questions. However, talkers vary in the amount of head and eyebrow movement that they produce, which affects perception of visual intonation. Speaking style further adds variability to both production and perception. In face to face conversations, visible head and eyebrow movement may compensate for reduced access to acoustic cues to speech intonation for listeners with hearing loss.

Poster #: 81

T35 Student Poster Award

Effects of Age of Acquisition on Word Recognition in Noise

Meredith Diane Braza, BS, The University of North Carolina at Chapel Hill, Durham, NC
Heather Porter, AuD, PhD, Boys Town National Research Hospital, Omaha, NE
Emilly Buss, PhD, The University of North Carolina at Chapel Hill, Chapel Hill, NC
Lauren Calandruccio, PhD, Case Western Reserve University, Cleveland, OH
Ryan McCreery, PhD; Lori Leibold, PhD, Boys Town National Research Hospital, Omaha, NE

Objectives: The purpose of the present study was to evaluate how age of acquisition (AoA) affects word recognition in noise for adults with normal hearing. Two primary predictions were made based on previous literature: 1) noise-masked word recognition would be better for early-acquired words than late-acquired words, and 2) there would be a positive correlation between vocabulary size and percent correct word recognition for later-acquired words.

Design: Participants were 27 adults (20-50 years) with normal hearing per self-report. Testing was performed using a lab-owned tablet and headphones delivered to the participant's home. Receptive vocabulary was assessed using the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4). Word recognition was assessed in speech-shaped noise at -5 and -7 dB signal-to-noise ratio (SNR). Targets were 240 disyllables from the corpus described by Kuperman et al. (2012). These words were selected to have an average AoA of either 4, 9, 12, or 15 years of age, with 60 words in each category. Target words were recorded by a native American-English-speaking male. Participants completed four 60-word lists, each containing an equal mix of words from each AoA category, and percent correct for each AoA was computed for each participant.

Results: A repeated-measures ANOVA indicates significant main effects of SNR and AoA of target words. There was a general trend for poorer performance with increasing AoA of target words. One exception was for early-acquired words at the -7 dB SNR; for this SNR, paired comparisons indicated better performance for words acquired at 9 years of age relative to words acquired at 4, 12, and 15 years. There was no evidence of a nonmonotonic effect of AoA at -5 dB SNR.

Conclusions: The results of this study are generally consistent with the idea that early-acquired words are easier to recognize than later acquired words, even when all words are within the lexicon of the listener. This result indicates that AoA is an important consideration when creating and interpreting clinical speech-in-noise tests. Follow-up studies are currently under way to better understand the apparent non-monotonicity in the effect of AoA at the more difficult SNR, including consideration of listener expectation regarding the vocabulary level of the test stimuli. Analyses will also be conducted on the differential effects of AoA and lexical frequency of target words on speech-in-noise performance.

Poster #: 82

T35 Student Poster Award

Feasibility of Remote Assessment of the Binaural Intelligibility Level Difference

Claire Marie Dorey, BS, University of Florida; Boys Town National Research Hospital, Gainesville, FL
Gabrielle R. Merchant, AuD, PhD; Heather L. Porter, AuD, PhD, Boys Town National Research Hospital, Omaha, NE
Emily Buss, PhD, University of North Carolina at Chapel Hill, Chapel Hill, NC
Lori J. Leibold, PhD, Boys Town National Research Hospital, Omaha, NE

Objectives: The objective of this study was to assess the reliability and feasibility of remote assessment of the binaural intelligibility level difference (BILD) in children using a three alternative forced choice word recognition task.

Design: Participants were 11 adults (22 - 45 years) and 28 children (6 - 17 years). All participants were native English speakers with self-reported normal hearing and no recent history of middle ear infection. Participants were asked to download an executable MATLAB program onto their personal computer and complete the

assessment using their own headphones. The task was a three alternative forced choice word recognition task presented in one of three conditions: in quiet, with the target and masker in phase between the two ears (M0T0, diotic condition), or with the target speech 180¬∞ out of phase and the masker in phase (M0Tπ, antiphasic condition). A speech recognition threshold (SRT) was measured for each condition, and the BILD was calculated as the difference between SRTs in the diotic and antiphasic condition. The quiet condition was always assessed first followed by masked SRTs in three blocks of two runs each. The noise conditions per block (M0T0 and M0Tπ) were randomized yielding three BILD estimates per day. Participants were assessed three times over the course of a week on Day 1, Day 2, and Day 7. The participant listened to the target speech and selected one of three images corresponding to the word they heard. Participants were also asked to collect and note the background noise level as well as any distractions that occurred during testing. Data collected in the remote setting were compared to previously collected BILD data from the laboratory.

Results: There was no significant correlation between the noise levels and the SRTs in quiet. Masked thresholds for both the M0T0 and M0Tπ conditions improved with age, but the BILD had no association with age. Mean remote BILD estimates were 5.8 dB for children and 6.1 dB for adults, consistent with previously published data. Remotely collected data from children fell within the 95% prediction intervals of the previously collected laboratory data in all but 4 cases. Intraclass correlations (ICCs) for comparisons of masked SRTs and the BILD revealed good reproducibility of the data between Day 1 and Day 2. In contrast, results from Day 1 and Day 7 were less consistent, particularly for the M0T0 condition. Notably, three participants (1 adult, 2 children) from the same family were outliers for both the M0Tπ condition and the BILD estimates. Post-hoc follow-up testing revealed these differences may have been due to the specific hardware (headphones) used.

Conclusions: Remote assessment of the BILD in children is feasible and generally reliable. All participants were able to perform the task, indicating feasibility. Consistency of BILD assessments between Day 1 and Day 2 indicate good reliability. There were, however, notable outlier data from a single family, likely due to the use of personal hardware. Hardware should be selected cautiously for remote assessments.

TINNITUS

Poster #: 83

Effects of Tinnitus Sound Therapy: Notched vs Non-Notched Stimulus

In-Ki Jin, PhD, Division of Speech Pathology and Audiology, Research Institute of Audiology and Speech Pathology, Hallym University, Chuncheon-si
Soon-Je Choi, BS; Minseung Ku, BS, Department of Speech Pathology and Audiology, Graduate School, Hallym University, Chuncheon-si
TaeRim Lee, Division of Speech Pathology and Audiology, College of Natural Sciences, Hallym University, Chuncheon-si

Objectives: The purpose of the current study is to compare the efficacy of stimulus type used in the tinnitus sound therapy at the mixing point level. The hypothesis states that the effects of sound therapy may vary on the basis of stimulus type.

Design: Thirty individuals suffering from chronic tinnitus participated in the present study. Sixteen subjects were assigned to a notched noise therapy group and fourteen subjects were assigned to a broad-band noise therapy group. In the beginning, 40 individuals participated, and they were randomly assigned to either of the two groups but 10 discontinued during the study. Both groups underwent sound therapy with the level set to the

mixing point for 12-months. Counseling was not provided. Score change between pre and post-treatment (12 months) session was measured using Tinnitus Primary Function Questionnaire, Korean version. All participants were instructed to undergo sound therapy for 3 hours, every day.

Results: Both groups showed significant decrement in Tinnitus Primary Function Questionnaire Scores. In the case of the notched noise therapy group, the average score changed from 54.41 to 22.31 and showed 32.10-point improvement. In the case of the broad-band noise sound therapy group, the average score changed from 47.88 to 12.57 and showed 35.31-point improvement. There was no statistically significant difference between the two groups.

Conclusions: At the mixing point level, both non-notched and notched type stimuli were equally effective in tinnitus sound therapy.

Poster #: 84

Heart Rate Variability in Individuals with Tinnitus following Acoustic Therapy
Paul Reinhart, PhD; Kendra Griffin; Christophe Micheyl, Starkey Hearing Technologies, Eden Prairie, MN

Objectives: Individuals with chronic, bothersome tinnitus exhibit dysregulation of the autonomic nervous system with a preponderance towards the sympathetic branch and suppression of the parasympathetic branch compared to healthy individuals. Many individuals with tinnitus achieve relief through acoustic therapy. The aim of the study was to investigate changes in autonomic function, as measured by heart rate variability, in individuals with tinnitus following acoustic therapy implemented using tinnitus maskers presented via hearing aids. We hypothesized that successful acoustic therapy is accompanied by an increase in parasympathetic activity, consistent with autonomic sympathetic-parasympathetic balance restoration in individuals with chronic, bothersome tinnitus.

Design: Twenty-six participants with tinnitus and hearing impairment completed an eight-week field trial wearing hearing aids providing acoustic therapy via three tinnitus masker options: 1. White noise masker, 2. Audiogram-shaped masker, and 3. Custom masker based on psychoacoustic measurements of minimum masking level. Participants were experienced hearing aid users but new to acoustic therapy via hearing aid maskers. Tinnitus handicap was measured using the Tinnitus Handicap Inventory at baseline (before starting acoustic therapy) and post-treatment (at end of eight-week trial). Resting heart rate and heart rate variability was measured using electrocardiography recorded at baseline and post-treatment.

Results: There was a significant decrease in tinnitus handicap post-treatment compared to baseline. There was no change in heart rate, as quantified by beats per minute, between post-treatment and baseline. There was a significant increase in heart rate variability, as quantified as the Root Mean Square of Successive Differences of inter-beat intervals, post-treatment compared to baseline.

Conclusions: Acoustic therapy using tinnitus maskers delivered via hearing aids provided tinnitus relief and produced a change in autonomic function, as indexed by an increase in heart rate variability. These findings were consistent with our hypothesis and suggest that heart rate variability is a potential biomarker for tracking efficacy of acoustic therapy.

Poster #: 85

Applications of Artificial Intelligence Technique in Predicting Tinnitus Intervention Outcomes

Hansapani Rodrigo, PhD, University of Texas Rio Grande Valley, Edinburg, TX
Vinaya Manchaiah, AuD, PhD, Lamar University, Beaumont, TX
Gerhard Andersson, PhD, Linkoping University, Sweden
Eldre Beukes, PhD, Lamar University, Beaumont, TX

Objectives: Not everyone with tinnitus is affected in the same way, as the perception and reaction to the tinnitus experience varies widely. There is a huge variability in the way individuals with tinnitus respond to interventions. These experiential variations together with a range of associated etiologies, contribute to tinnitus being a highly heterogeneous condition. Despite this heterogeneity, a "one size fits all" approach is taken when making management recommendations. Although there are various management approaches, not all are equally effective. Psychological approaches such as cognitive behavioral therapy (CBT) have the most evidence-base. However, the studies so far have examined group effects and there is little knowledge on the predictors of outcomes. Our previous efforts on using traditional statistical methods have not resulted in identification of any key predictors. In the current study, we have applied Artificial Intelligence (AI) techniques on a dataset of individuals who underwent Internet-based CBT (ICBT) to examine the predictors of intervention outcomes as well as to identify the participant group that are most/least likely to be benefited.

Design: 228 individuals with tinnitus who underwent ICBT in three different trials were included in this study. A positive treatment effect was defined as a reduction of 13-points following the intervention on the Tinnitus Functional Index (TFI). Various demographic (e.g., age, gender, education), tinnitus related (e.g., type of tinnitus, duration of tinnitus, previous treatment) and comorbidities (e.g., anxiety, depression, insomnia) were used as predictor variables. AI techniques with various decision trees, and random forest were applied on this data to examine the predictors of outcomes and to identify participant groups who are most likely to be benefited.

Results: The CART decision tree and gradient boosting models (GB) resulted in identification of some key factors (e.g., education level, baseline tinnitus severity) that may influence the ICBT outcomes. The predictive models based on CART and GB had a mean AUC of 0.69 (SD:0.001) and 0.68 (SD:0.02), respectively. Though, not strong, these classifiers show moderate discrimination power in distinguishing the participants who tend to yield successful outcome with the treatment. Characteristics. In fact, three participant group had shown at least 85% success with the ICBT intervention, including the participants who had an education master's level or above. Including additional factors into the models and also testing these models in a larger dataset (n>1000) may help increase the predictive accuracy.

Conclusions: The proposed research in this project is the first step to determine individual variations in tinnitus management and building predictive models. We believe that this research may help choose right intervention based on individual variations and help achieve optimal outcomes at individual patient level. While the current study focuses on a small, well-defined population, the future work will focus on extending this approach to a larger clinical sample of patients. Using AI techniques on a larger dataset may provide more clearer understanding of who would benefit from what kind of psychological treatments and will help in fine-tuning the content, presentation, and process-flow of internet-based psychological treatments. Overall, this initiative has the potential to help achieve the vision of precision medicine.

Poster #: 86

Use of Open-ended Questions to Examine Consequences of Tinnitus

Vinaya Manchaiah, AuD, PhD, Lamar University, Beaumont, TX
Gerhard Andersson, PhD, Linkoping University, Sweden
Marc Fagelson, PhD, East Tennessee State University, TN
Ryan Byod, PhD, Lancaster University, UK
Eldre Beukes, PhD, Lamar University, Beaumont, TX

Objectives: Tinnitus is a heterogeneous condition which may influence routine activities of those affected such as attention, concentration, and sleep, in addition to exacerbating depression and anxiety. Generally, standardized patient-reported outcome measures (PROMs) are used in the assessment of tinnitus consequences. However, such assessments are limited and may lack generalizability owing to the measurement scale used. Open-ended questions may facilitate capturing patients' views, although the traditional qualitative methods alone are not sufficient for this purpose. The primary aim of the study was to examine automated linguistic analysis of open-ended problem (PQ) and life-effects (LEQ) questionnaires to glean information regarding the psychological effects of tinnitus.

Design: The study included a cross-sectional survey design (n=336). Participants included individuals with tinnitus who completed online questionnaires which included demographic questions, standardized PROMs related to tinnitus distress, anxiety, depression, insomnia, and quality of life and two open-ended questions that served as PQ and LEQ related to tinnitus. The response to open-ended questions were analyzed using the Linguistic Inquiry Word Count (LIWC) software to quantify psycholinguistic dimensions relevant to tinnitus within each text.

Results: Automated linguistic analysis of PQ and LEQ resulted in different dimensions. For example, PQ elicited a significantly higher words related to *analytical thinking*, *social processes, body*, *perceptual processes, hearing, work* and *leisurely activities*, whereas the LEQ elicited a significantly higher *I-words* and the words related to *negative emotions* and *health*. The correlation between open questions and PROMs point to two broad findings. First, although PQ and LEQ have some similarities with PROMs (e.g., the linguistic dimension *negative emotions* having a weak positive correlation with anxiety and depression), no correlation with number of dimensions suggest that the open-ended questions identify additional elements that are not captured in PROMs. Second, the greater number of linguistic dimensions from the PQ correlate with PROMs compared to LEQ suggesting that the current PROMs are problem oriented.

Conclusions: The study results suggest that responses to open-ended questions illuminate different consequences of tinnitus than those provided in more widely-used PROMs. These results support the idea that use of open-ended questions in addition to PROMs may improve assessing the effects of chronic heterogeneous conditions such as tinnitus. Moreover, automated text analysis focusing on linguistic variables may help analyze the open-text response quickly and in a manner that supports clinically-relevant applications. Overall, these findings have implications to health and medical research methodology specifically to develop the way outcomes are measured in various chronic conditions.

Poster #: 87

What Can we Learn about Tinnitus from Social Media Posts?

Vinaya Manchaiah, AuD, PhD, Lamar University, Beaumont, TX
Manon Revel, MS, Massachusetts Institute of Technology, Institute for Data, Systems and Society, MA
Guillaume Palacios, PhD, PainkillAR, TELECOM ParisTech, Paris, France

Alain Londero, PhD, Service d'Oto-Rhino-Laryngologie et Chirurgie Cervico-Faciale
Aniruddha Deshpande, PhD, Hofstra University and Long Island AuD Consortium
Ryan Boyd, PhD, Lancaster University, UK
Pierre Ratinaud, PhD, Laboratory of Applied Studies and Research in Social Sciences, University of Toulous, France

Objectives: Individuals with tinnitus are highly heterogeneous in terms of etiology, manifestation of symptoms, and the way they manage their condition. Most of these patients are likely to seek hearing health information and social support online via various websites or social media platforms. Indeed, information is easily accessible online. Further, in absence of evidence-based tinnitus care, patients with similar symptoms can regroup, share experiences and exchange tips. Even after consultation with healthcare providers, some of the patients continue seeking for information online when they feel they did not get satisfying information about treatment options and/or about their prognosis. The present study was aimed at examining the discussions around tinnitus in Reddit posts using various Natural Language Processing (NLP) techniques. In particular, we examined the free-texts posts to understand the types of conversation about tinnitus in an online forum and the way in which people with tinnitus reach out to other people for support (informational, emotional, etc.) when coping with their conditions.

Design: The study used a cross-sectional design. A search was performed using key words such as "tinnitus" to identify threads specifically discussing tinnitus. Data from these threads were extracted using the Reddit application programming interface (API) with a custom-built script, resulting in a corpus of 130,000 posts. After cleaning the data for posts without any text and duplicates, a text corpus with 101,000 posts was built which was analyzed using various automated NLP techniques including: (a) hierarchical cluster analysis; (b) unsupervised machine learning (ML) - Latent Dirichlet Allocation (LDA) algorithm; and (c) supervized sentiment analysis.

Results: The cluster analysis resulted in a 16-cluster solution. Some of these clusters have information that has been discussed in relation to tinnitus from previous qualitative and social media studies (e.g., causes, factors influencing tinnitus, hope for cure, coping), although some clusters identified discussion around new themes that were not discussed in previous literature (e.g., supplements, personal timeline). The LDA analysis identified a 16-factor solution and these results were comparable to the cluster analysis. Further, the sentiment analysais showed that there was a statistically significant difference in semintent among different factors.

Conclusions: The current study results suggest that examination of free-text responses in social media messages help uncover new dimensions about tinnitus that have not been discussed in the literature. As Reddit posts are anonymous and written with the user's own wish, it is likely that the ecological validity of such data is high. The current study findings help develop appropriate patient-centered strategies to support individuals with tinnitus.

ELECTROPHYSIOLOGIC RESPONSES

Poster #: 88

Blood Pressure Level, Auditory Brainstem Responses, and Electrocochleography
Katherine Lemons, BA; Caitlin Berry, MS; Eric Vance, PhD; Rachael Baiduc, PhD, University of Colorado Boulder, Boulder, CO

Objectives: Many cardiovascular disease risk factors may contribute to the development of hearing loss, including hypertension. Previous population-based and clinical studies are mixed regarding the association between high blood pressure (BP) and auditory function. Little work has been done in individuals with BP elevation that is not severe enough to be classified as hypertension. The present study aims to evaluate the relationship between elevated BP and early auditory evoked potentials (AEPs), specifically auditory brainstem responses (ABRs) and electrocochleography (ECochG).

Design: Fifty-two subjects (44% female) aged 18-55 years were classified as having either optimal BP (systolic<120 and diastolic BP<80 mmHg; n=25) or nonoptimal BP (systolic ≥120 or diastolic BP ≥80 mm Hg or antihypertensive use, n=27). Fifteen individuals in the nonoptimal group had hypertension (systolic BP ≥130 or diastolic BP ≥80 mm Hg or antihypertensive use). Behavioral hearing thresholds were obtained from 0.25 to 16 kHz and three puretone averages (PTAs) were computed: low (0.5, 1, 2 kHz), mid (4, 6, 8 kHz), and high (10, 12.5, 16 kHz). Threshold ABRs were recorded using rarefaction clicks (17.7/sec). Electrocochleograms were obtained with 90 dB nHL alternating clicks (7.1/sec) and assessed for summating (SPs) and compound action potentials (APs). Outcomes were first compared using independent samples t tests. Bivariate correlations were used to assess the relationship between ABR wave latency and BP levels. Last, linear mixed effects models were constructed for response variable ABR wave (I, III, V) latency with fixed effects (stimulus level, BP, test ear, recreational noise exposure, and sex) and random effects (subject).

Results: Compared to the nonoptimal group, the optimal BP group had significantly lower thresholds based on all three PTAs. Between-group ABR latency differences were significant for wave V at the highest stimulus level (p=.048). Correlations between BP level (systolic and diastolic) and ABR wave latency were weak although diastolic BP was significantly correlated with wave V latency (r=0.295; p=0.039). Comparison of ABR latencies between subjects with optimal BP vs. hypertension revealed significantly longer wave V latencies in hypertensives at three stimulus levels: 80 (p=.033), 50 (p=.038), and 30 dB nHL (p=.040). Wave I latency was significantly longer in the hypertensive group vs. the optimal BP group at 70 dB nHL (p=.016). The best linear mixed model to fit wave V predicted latency using stimulus level, sex, and age. Addition of BP level did not improve model fit. Wave I data were best fit by a model that included sex, age, and noise exposure. The nonoptimal BP group had significantly higher AP amplitudes than the optimal BP group (p=0.047); average SP/AP ratios did not significantly differ between groups. Last, hypertensive subjects had significantly higher SP and AP amplitudes than persons with optimal BP (SP: optimal BP, 0.10 [0.12] v. hypertensive, 0.25 [0.14] microV; p=0.021; AP: optimal, 0.46 [0.20] vs. hypertensive, 0.71 [0.30] msec; p=0.02).

Conclusions: These preliminary data suggest that hypertension (but not slightly elevated BP) might be associated with subtle alterations in early AEPs. As hypertension is a prevalent and modifiable risk factor, its possible association with altered AEPs warrants further study in a larger investigation.