XXV INTERNATIONAL EVOKED RESPONSE AUDIOMETRY STUDY GROUP BIENNIAL SYMPOSIUM, 21–25 MAY 2017, WARSAW

Hallowell Davis Lecture – John D. Durrant

Moderator: Suzanne Purdy

Unpublished Works and the Importance of Continuing to Turn Stones in Our Science

John D. Durrant

Professor Emeritus, Communication Science and Disorders, School of Health and Rehabilitation Sciences, University of Pittsburgh; Research Scientist, Intelligent Hearing Systems, Miami FL, USA

In the perfect scientific world and following rigorously the scientific method, no research study would go unpublished. Yet, researchers prove that they too are human, extenuating circumstances arise, and publication is naturally not the only means to achieve (at some level) the same objective--that of exchange of ideas and information. The IERASG Biennial Symposia have provided a rich and inviting forum for such exchange in a rarefied, yet highly important area of hearing science and health care for over half a century, remaining true to its founder's intent. A variety of the presenter's findings, particularly those "aired out" at the Biennial Symposia over a period of four decades are cataloged, reflecting as well some of the shifting interests of the times. Some studies noted perhaps left a stone or few "unturned". Yet, the overall contention is that research begins by turning stone(s) at the curiosity of the researcher which would be fettered were one's motivation to be uniquely a 100% conversion rate to publication and/or other motives. The biennial "forum" provides healthy interactive opportunities by which the researcher may ultimately bring a given work to true maturity or simply weigh the merits of further pursuit, as well as potentially opening the door to collaboration(s). The unpublished works to be covered are exemplary of those begging further consideration. They are presented with the hope that others might derive motivation to take on bringing some to fruition. In any event, more than a summary of the presenter's contributions over the years, this presentation is a tribute to the collegial environment of the Biennial Symposia and the spirit of Hallowell Davis' visionary formation of the evoked response "club", which strongly motivated this presenter's efforts to faithfully participate.

Keynote Lecture I – John J. Rosowski

Moderator: M. Patrick Feeney

Wideband Acoustic Immittance and Sound Power Absorbance as a Measure of the Acoustic Reflex

John J. Rosowski

Eaton-Peabody Laboratory, Massachusetts Eye and Ear Infirmary, Boston, MA USA

Objectives: The history and physics of Wideband Acoustic Immittance and Sound Power Absorbance will be reviewed from the 1930s till present day.

Material and methods: The discussion will include the development of tympanometry and arguments for expanding the frequency range of immittance measurements to improve its sensitivity to changes introduced by varied disease states.

Results: The use of multiple frequencies makes wide-band immittance and power absorbance a sensitive measure of the acoustic reflex.

Conclusions: Sound-induced changes in acoustic immittance and power absorbance can be used as measures of the acoustic reflex.

Keynote Lecture II – Frank E. Musiek

Moderator: David McPherson

The Middle Latency Response (MLR) and Disorders of the Central Nervous System

Frank E. Musiek

University of Arizona, USA

The development and application of the (auditory) Middle Latency Response (MLR) has had a long and somewhat challenging journey. Although its research and clinical use has waned in recent history, the evoked potential community may wish to revisit the potential of the MLR. One area of promise, often overlooked, is the MLR's utility as a measure of central auditory nervous system (CANS) integrity. Our experimental and clinical experience with the MLR, corroborated by published reports from other labs, confirms the MLRs sensitivity to compromise of the CANS. In this review of our work as well as others, the insights gained from the MLR for various disorders of the CANS will be highlighted. MLR results for brainstem and cortical

lesions across various indices will be discussed in regard to its overall sensitivity and specificity. In addition, profiles of relevant case studies will be offered to substantiate our view that clinicians and researchers reconsider use of the MLR in the lab and in certain circumstances, the clinical arena.

Guest Lecture I – John A. Ferraro

Moderator: John D. Durrant

Electrocochleography in the Diagnosis and Possible Prediction of Meniere's Disease/ Endolymphatic Hydrops

John A. Ferraro

Hearing and Speech Department, University of Kansas Medical Center, Kansas City, USA

The use of Electrocochleography (ECochG) in the identification, assessment and management of Meniere's disease/ endolymphatic hydrops (MD) is well documented in the literature. This presentation will focus on methods developed in our laboratory that have improved the sensitivity and specificity of ECochG for this particular clinical application. Data were derived from non-invasive TM recordings and involved measurement of both the SP/AP amplitude and area ratios. Sensitivity and specificity values for ECochG in comparison to other tests commonly used to help diagnose MD (i.e., VNG, VEMP, rotary chair) also will be presented. In addition, we have recently completed a pilot study designed to assess whether ECochG might also be valuable as a screening tool to help predict MD in individuals who may be genetically predisposed to developing it. ECochG was performed on a small sample of subjects with no history/symptoms of MD, but are either the offspring or siblings of individuals with a confirmed diagnosis of this disorder. Preliminary findings showed that the family members have a much higher incidence of positive electrocochleograms in comparison to the general, non-MD population. Finally, attention will be called to the lack of (and need for) standardization of ECochG recording and measurement protocols, which makes it difficult to compare/share results across clinics/clinicians and most certainly has affected the outcomes of several studies related to the effectiveness of ECochG as a clinical tool.

Guest lecture II – Paul Kileny

Moderator: John D. Durrant

Tympanic Electrocochleography in SSCD: Diagnostic, and Intraoperative Monitoring Applications

Paul Kileny

Department of Otolaryngology, Head-and-Neck-Surgery, Michigan Medicine, University of Michigan, Ann Arbor, USA

Hallowell Davis, the founder of IERASG was the first to demonstrate in the 1950's, that changing the pressure in the scala tympani, and the static position of the basilar membrane resulted in a change in polarity of the summating potential (SP). Subsequently, transtympanic electrocochleography (ECochG) was recognized as an effective tool in the diagnosis, of Meniere's disease (MD)/endolymphatic hydrops (ELH). More recently, our group has shown that tympanic EcochG has a high sensitivity in the diagnosis of superior semicircular canal dehiscence (SSCD)/third window conditions. Using computed tomography as the standard, elevation of SP/AP on ECochG (0.40<)demonstrated 89% sensitivity and 70% specificity for SSCD. The mean SP/AP ratio among ears with SSCD was significantly higher than that among unaffected ears ($p<0.0001$). During occlusion procedures, the SP/AP increased on exposure of the canal lumen (mean change ± standard deviation, 0.48±0.30). After occlusion, the SP/AP dropped below the intraoperative baseline in most cases (mean change, −0.23±0.52). All patients experienced symptomatic improvement. All patients who underwent postoperative ECochG 1 to 3 months after SSCD repair maintained SP/AP of 0.4 or less. This presentation will detail our tympanic EcochG technique, and highlight its diagnostic and intraoperative application in patients with SSCD, illustrated by case studies.

Guest lecture III – Mridula Sharma

Moderator: Barbara Cone

Applications of auditory evoked potentials in understanding ABC: Auditory processing, bilingualism and cognition

Mridula Sharma

Audiology, Department of Linguistics, Macquarie University and HEARing Co-operative Research Centre, Australia

This presentation discusses research on CAEPs and the neural oscillations that underlie the CAEP components. Results from four studies where CAEPs and neural oscillations were utilised to investigate auditory processing, bilingualism and cognition. Four studies that investigated using speech tokens to evaluate mechanisms involved in auditory processing, effect of bilingualism and the role of attention and statistical learning. Significant differences on the various paradigms were observed and will be presented. CAEPs can be utilised to evaluate auditory and/or non-auditory factors. With currently available signal processing techniques, we may be able to better explore underlying mechanisms for a variety of auditory tasks in a range of populations.

Monday, May 22nd

ABR I

Moderators: Guy Lightfoot, Martin Walger

The threshold ABR high-pass filter re-visited: An old chestnut served up in a new way

Guy Lightfoot

ERA Training and Consultancy Ltd.

Objectives: To measure the ABR SNR when 30, 50 and 100 Hz filters are used in quiet and restless patient conditions after 60s of averaging regardless of whether some of that time was wasted rejecting epochs- a real-life scenario that differentially penalises 30 Hz.

Material and methods: Using an artifact rejection level of ±10 μV and noise-weighted averaging, the raw data from 12 sleeping and 12 restless babies was re-averaged with the 3 high-pass filters and the SNR was measured.

Results: Response amplitude, residual noise and SNR declined with increasing filter frequency for both groups but whilst 30–100 Hz filter SNR difference was significant for the sleeping group (p=.004) it was not significant for the restless group (p=.2).

Conclusions: The high-pass filter of choice for threshold ABR testing is 30 Hz. The use of 100 Hz is disadvantageous in relaxed babies. There is no gain in raising the filter to 100 Hz, in restless patients.

Comprehensive recording of auditory evoked potentials by projecting over a base of functions

Joaquin Tomas Valderrama Valenzuela[1,2,3], Angel de la Torre[4], Bram Van Dun[1,2], Jaime Undurraga[3], Jose Carlos Segura[4], Harvey Dillon[1,2,3], David McAlpine[3]

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[2] *HEARing Co-operative Research Centre, Australia*
[3] *Department of Linguistics, Macquarie University, Australia*
[4] *Department of Signal Processing, Telematics and Communication, University of Granada, Spain*

Objectives: To develop a stimulus and a processing algorithm that allows the recording of all auditory evoked potentials from the cochlea to the auditory cortex, thus obtaining a single signal consisting of the ABR, MLR and CAEP components.

Material and methods: Stimulus consisted of 400 bursts of 7 clicks (ISI [10–40] ms) presented at an average rate of 1 Hz. Analysis consisted of averaging a time window of 500 ms, and projecting over a base of functions uniformly distributed in the logarithmic time scale.

Results: The signals resulting from projecting over the base of functions show replicable auditory evoked potentials with latencies compatible with ABR, MLR and CAEP components in all subjects and recording conditions.

Conclusions: Projecting over the defined base of vectors is a reliable method for latency-dependent filtering, which, together with the proposed stimulation paradigm, allows the simultaneous recording and visualization of ABR, MLR and CAEP components.

A group sequential test strategy for objective auditory brainstem response detection methods

Michael A. Chesnaye, Steven L. Bell, James M. Harte, David M. Simpson

Institute of Sound and Vibration Research, University of Southampton, United Kingdom
Interacoustics Research Unit, c/o Technical University of Denmark, Lyngby, Denmark

Objectives: A novel statistical approach for rapidly detecting auditory brainstem responses using a sequence of tests is proposed. Its performance is evaluated in terms of specificity, sensitivity and test time and is compared to a conventional single shot test.

Material and methods: Performance was evaluated using multiple simulations, along with real EEG background activity (recorded from 20 individuals) and ABR threshold data (recorded from 12 adults, using clicks presented at 33.3 Hz at various dB SL).

Results: No significant ($p<0.05$) deviations from the expected false positive rates (FPRs) were observed, which suggests that specificity was controlled as intended. Results furthermore show a trade-off between detection time and sensitivity.

Conclusions: The proposed method allows the repeated application of an objective ABR detection method, whilst maintaining the expected FPR. The method provides relatively large reductions in detection time (~40%), with potentially no loss in statistical power.

Comparative study of noise in auditory brainstem evoked potentials recorded asleep and in active state

Oleg Belov, Alla Yasinskaya, George Tavartkiladze

National Research Centre for Audiology and Hearing Rehabilitation, Moscow, Russia

Objectives: We studied the noise in the data stream while the ABR registration in adults during the relaxation both in supine and seated positions and in active state in seated position, where the person was having a conversation and was gesticulating.

Material and methods: The data were recorded using Tucker-Davis "System 3" station. A data from accelerometers,

gyroscopes and a microphone located on the head were recorded synchronously by the same station. Continuous data stream was stored for off-line processing.

Results: The epochs adjacent to artefacts produced by blinking of the eyes where removed. Spectra of the remaining noise were not significantly different between conditions except deep relaxation. No correlations with the head motion and speech were detected.

Conclusions: We believe that the appropriate processing of the continuous data stream before averaging can improve the ABR recording procedure in cases when sleeping is not possible.

ABR II

Moderators: Monica Chapchap, Krzysztof Kochanek

Maturation of ABR in young children with congenital monaural atresia

Martin Walger, Astrid Foerst, Dirk Fuerstenberg, Ruth Lang-Roth, Konrad Stuermer

Department of Otorhinolaryngology, Head and Neck Surgery, Audiology and Pediatric Audiology, Cochlear Implant Center, University of Cologne, Germany

Objectives: To date, the impact of a sound conductive hearing loss on the auditory pathway at brainstem level has only been investigated in animal studies, where a delay of ABR inter-peak-latencies as well as changes of binaural interaction could be observed.

Material and methods: In a clinical study, the functional maturation of ABR parameters (latencies and IPL) in children with unilateral congenital atresia was investigated. For this reason, 42 newborns and toddlers ranging in age from 13 days to 11 months were included.

Results: No significant difference between ABR interpeaklatencies of normal ears and ears with congenital atresia could be detected and furthermore no differences could be observed in comparison to bilateral normal hearing children.

Conclusions: The early monaural deprivation by SCHL does not change auditory processing on brainstem level. Posssible deficits of binaural interaction or auditory processing disorders at higher levels of the auditory pathway cannot be excluded.

Cardiac activity appears to be the cause of a sloping ABR waveform

Guy Lightfoot

ERA Training and Consultancy

Objectives: In an earlier study into the effect of artifact rejection (AR) level, some sloping ABR waveforms were recorded and the slope often changed with the AR. This study investigated whether ECG is responsible and suggests a mechanism.

Material and methods: Ten raw EEG records with ECG were selected. For each, the ABR waveform was averaged using an AR of ±5 μV and ±10 μV. All had a slope (^{3}100 nV) at one or other AR level. The ECG epochs were deleted from the records and the averaging repeated.

Results: In all cases the waveform slope was abolished or substantially attenuated following ECG removal.

Conclusions: It is highly likely that in the cases studied, it was the cardiac activity that gave rise to the observed sloping ABR baseline. A possible mechanism for this effect will be presented.

Auditory electrophysiological assessment in neonates with zika virus congenital syndrome

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Objectives: To describe the findings of the auditory electrophysiological assessment in neonates with Zika Virus Congenital Syndrome (ZVCS) born at the state of Rio de Janeiro and with a documented clinical and/or radiological diagnosis of ZVCS.

Material and methods: The study consisted of 45 male 66 female neonates. Procedures: Click-ABR at 80 dB nHL; air conduction (AC) FS-ABR with NB-CEChirp (0.5 and 2 kHz) at 35/30 dB nHL. In case of impairments: AC 1 and 4 kHz and BC FS-ABR (0.5, 1, 2, 4 kHz).

Results: M: 70% normal (NL) 6.6% cochlear microphonism (CM) 11.2% conductive impairment (CI) 6.6% increased absolute latencies (AL) 2.2% SHL 3.3% neural impairment (NI)F: 59.9% NL 5.3% CM 9.1% CI 1.5% increased AL 18.9% decreased AL 1.5% SHL 3.8% NI.

Conclusions: Higher number of impairments in the female. Neonates with sensorineural hearing loss also can have other risk indicators for this impairment. Through the present study it can be observed that hearing loss can not be attributed exclusively to ZVCS

Side effects of stimulus polarities with Level-Specific CE-chirps in clinical ABRs

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Objectives: The use of broadband level-specific (LS) CE-chirp in ABR measurements seem to evoke more prominent and recognizable evoked potential (EP) wave forms and therefore a shorter test time regarding auditory threshold measurements.

Material and methods: Latency and morphology changes with different polarity have been examined for broad- and narrow-band LS-chirps. Differences within and between polarities, i.e. condensation and rarefaction, have been examined within and between subjects.

Results: No significant changes for BB and NB 2 kHz/4 kHz chirps. However, 500 Hz/1 kHz show significant latency changes with different polarities. Substantial differences were found for different polarities (+) and (–) for the lower frequencies.

Conclusions: Summed polarity response ABR for 500/1 kHz LS-chirps result in different peak latencies/artifacts and might cancel out EPs, due to peak latency shifts between polarities. Instead of just alternating (=default), averaging (+) and (–) EPs are advised.

Methodological Approaches to Recording Speech Auditory Brainstem Responses: Effect of Stimulus Duration, Background, Consonant, and Number of Repetitions

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Objectives: This study aimed at systematically evaluating the effect of stimulus duration, background (quiet versus noise), and consonant type on speech-ABRs, and at evaluating the minimum number of repetitions required to record clear speech-ABRs.

Material and methods: Speech-ABRs evoked by 40-ms [da], 50-ms [ba] [da] [ga], and 170-ms [ba] [da] [ga] were collected from 12 normal-hearing adults in quiet and noise using a two-channel vertical electrode montage.

Results: Statistically significant effect of duration and background on latencies and amplitudes ($p<0.01$), no significant effect of background on FFR phase locking to F0, no effect of consonant type on latencies and amplitudes.

Conclusions: In normal-hearing adults: 1) shorter stimuli may be used for speech-ABRs; 2) the effect of noise on speech detection can be assessed using speech-ABR regardless of stimulus duration; 3) the speech-ABR should not be used for consonant discrimination.

Forward Masking of the Speech-Evoked Auditory Brainstem Response

John H. Grose, Sarah Hodge

University of North Carolina at Chapel Hill

Objectives: Older listeners with normal audiograms exhibit speech-in-noise difficulties in part due to increased temporal masking. This study measured forward masking of the speech-evoked ABR as an objective measure of temporal processing ability.

Material and methods: Forward-masked sABRs were measured in normal-hearing adults using a /da/ signal preceded by a 100-ms speech-noise masker; masker=75 dB SPL, signal=70 dB p-peSPL. Masker-signal interval (Δt) was 4, 16, 32, 64 ms. Peak latencies were measured.

Results: In young adults, latency varied inversely with Δt, especially for the initial peak. Later peaks showed less systematic shifts. Preliminary data from older listeners suggest a similar behavior but with latency shifts extending out to later peaks.

Conclusions: Forward-masked sABRs provide a viable and objective measure of temporal processing that appears to be sensitive to listener age.

Click and Speech-ABR assessment in children with history of otitis media unilateral and bilateral

Milaine Dominici Sanfins[1], Leticia Reis Borges[1], Caroline Donadon[1], Piotr H. Skarzynski[2,3,4], Maria Francisca Colella-Santos[5]

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Objectives: This study aimed to determine the long-term effect of otitis media on Click and Speech-ABR assessment in children and adolescent with history of otitis media (who have undergone bilateral and unilateral tympanostomy tube placement surgery).

Material and methods: The subjects were divided into three groups: CG – 40 typically developing children, SG1–50 children with bilateral tympanostomy and SG2–16 children with unilateral tympanostomy. Click ABR – 80 nHL. Speech ABR – 80 SPL for speech stimuli.

Results: Click ABR: latencies – no significantly difference, amplitude difference for wave III and V. Speech-ABR: latencies – difference for the all waves on both ears ($p<0.05$), amplitude difference for waves V and A.

Conclusions: The findings highlight the risk on auditory system deficit for children with middle ear disease history and subsequent bilateral or unilateral tympanostomy grommets surgery in childhood.

The potential role of the cABR in assessment of normal hearing adults with inherited neuropathies

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[6] *Department of Otorhinolaryngology – Head and Neck Surgery, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine*

Objectives: The aim of this study was to investigate 1) the auditory pathway function and 2) the potential role of the complex auditory brainstem response (cABR) in a group of normal hearing (NH) adults with inherited neuropathies.

Material and methods: Thirty-five NH adults with Charcot-Marie-Tooth (CMT) disease and 48 heathy NH listeners participated. We assessed speech in noise perception and recorded ABRs to three speech syllables. We calculated F0 amplitude and average phase-shift values.

Results: CMT patients showed significantly higher SNR thresholds than control group. Speech in noise perception was significantly correlated with phase difference between /DA/ and /BA/ after controlling age, sex, and pure-tone thresholds.

Conclusions: While CMT patients had normal pure tone thresholds, they were difficult to understand in noisy background. Speech perception in noise ability was significantly correlated with subcortical auditory processing of speech

ABR III

Moderators: Lee-Suk Kim, Lech Sliwa

Auditory brainstem responses (ABR) in dolphins obtained with maximum length sequence (MLS) and randomized stimulation and averaging (RSA) techniques

Robert Burkard, James J. Finneran, Jason Mulsow

Department of Rehabilitation Science, University at Buffalo; U.S. Navy Marine Mammal Program, Space and Naval Warfare Systems Center Pacific; National Marine Mammal Foundation

Objectives: To compare the effects of click rate and level on the ABR of bottlenose dolphins using conventional averaging, MLS and RSA.

Material and methods: ABRs were obtained at 25 Hz and 100 Hz (conventional) and rates of 100–1250 Hz (MLS/RSA) at a fixed level, and click-level series were obtained at select rates. ABRs were recorded in 3 normal hearing (NH) and 3 hearing-impaired (HI) dolphins.

Results: ABR amplitudes were reduced in HI dolphins. Peak latencies increased and amplitudes decreased with increasing rate and decreasing level. ABR similarities and differences for rate and level effects of MLS versus RSA will be presented.

Conclusions: Dolphin ABRs to MLS/RSA look similar to conventional ABRs, and rate/level effects are similar to those observed in other species. The effects of the reduced jitter of RSA compared to MLS on the ABR will be discussed.

Derived narrow-band auditory brainstem responses to the biosonar click of the bottlenose dolphin (Tursiops truncatus)

Jason Mulsow, James J. Finneran, Dorian S. Houser, Carolyn E. Schlundt

National Marine Mammal Foundation, USA
U.S. Navy Marine Mammal Program, Space and Naval Warfare Systems Center Pacific, USA
National Marine Mammal Foundation, USA
Harris Corporation, USA

Objectives: The biosonar signals of bottlenose dolphins are broadband clicks. The spectral and temporal characteristics of these clicks as heard by the dolphin are, however, unknown. This study examined the neural coding of clicks in the dolphin auditory system.

Material and methods: Dolphins were trained to echolocate on an underwater target in the presence of masking noise. The subtractive high-pass noise technique was used to derive narrow-band auditory brainstem responses to the dolphins' outgoing clicks.

Results: Peak latencies for narrow-band responses to biosonar clicks were similar for frequency bands of approximately 28 to 113 kHz. This contrasted with narrow-band peak latencies for passively delivered clicks, which decreased with increasing frequency.

Conclusions: The neural representation of the dolphin's click is highly synchronous and shows less latency change with frequency than observed for external click stimuli. This has implications for comparisons between emitted clicks and returning target echoes.

Profile of auditory function in audiometrically normal humans with a history of loud music exposure

John H. Grose

Departament of Otolaryngology – Head and Neck Surgery, University of North Carolina at Chapel Hill

Objectives: Animal work demonstrates cochlear synaptopathy subsequent to TTS. Here, audiometrically normal adults with a history of loud music exposure were assessed using both behavioral and electrophysiological measures of suprathreshold auditory function.

Material and methods: Loud-music-exposed (n=31) and control (n=30) subjects were tested with ABR, EFR, ACC, and DPOAEs, as well as psychoacoustic and speech tests. The latter included spectral/temporal modulation detection, IPD, and filtered word and sentence recognition.

Results: The two groups differed on the derived ABR Wave I/Wave V amplitude ratio which was smaller in the loud-music-exposed subjects. Absolute Wave I amplitudes did not differ significantly. There were no group differences on any other measure.

Conclusions: Whereas a reduced Wave I/Wave V amplitude ratio appears consistent with cochlear synaptopathy subsequent to TTS, failure to find any effects on other measures highlights the elusiveness of a robust, quantitative profile of hidden hearing loss.

Delayed D-methionine Administration Post-Noise Cessation, Significantly Rescues Permanent Auditory Brainstem Response Threshold Shift in Chinchillas

Kathleen C.M. Campbell, Robert Meech, Steve Verhulst, Daniel Fox

Department of Medical Microbiology, Immunology, and Cell Biology Southern Illinois University School of Medicine Springfield, Illinois United States of America

Objectives: D-methionine (D-met) reduces noise induced hearing loss (NIHL) even if administered after noise. This study's purpose was to determine maximum time delay for effective D-met post-noise NIHL rescue measured by auditory brainstem response thresholds.

Material and methods: 15 chinchilla groups received steady state or impulse noise. BID D-met or placebo started 7, 9, 12, 18, 24, 36, or 48 hours after noise and then another 48 hours. BID. ABR threshold shift from baseline was measured at 21 days post-noise exposure.

Results: : D-met significantly reduced NIHL ABR threshold shift ($p \leq 0.01$) for steady state and impulse noise even when administration began up to 36 hours post-noise exposure. Optimal protective dosing delay time occurred up to 24 hours post-noise exposure.

Conclusions: D-met rescue is significantly effective with delays to 36 hours post-steady state or -impulse noise exposure. Results may have significant clinical impact for optimal effective D-met protection from NIHL, particularly for unexpected noise exposures.

Electrocochleography

Moderators: John A. Ferraro, John D. Durrant

Long term monitoring of the inner ear function during and after Cochlear Implant insertion using Cochlear Microphonics

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Objectives: To preserve residual hearing during CI surgery it is desirable to use intraoperative monitoring during the electrode insertion. Here the relation of cochlear microphonics (CM) to the long term hearing preservation shall be investigated.

Material and methods: During the insertion of hearing preservation electrodes extra- and intracochlear CM recordings were performed. The follow up recordings take place up to one year after insertion. Up to now 10 patients are included having passed diverse appointments.

Results: Extracochlear recorded CMs showed peaks of maximal 0.5 µV in the according spectra. Intracochlear peaks of up to 30 µV were detected. In the first data, the amplitude of long term CMs seem to be in line with the audiometrical pure tone thresholds.

Conclusions: The recording of CMs is very good possible with both methods. The amplitudes of intracochlear recorded CMs were detected to be much larger than the extracochlear recorded CMs.

TT-ECochG recorded at high stimulus rate in patients with Meniere disease

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[2] *Intelligent Hearing Systems, Miami, FL, USA and University of Miami, Biomedical Engineer, Coral Gables,FL, USA*

Objectives: To investigate auditory evoked responses recorded from the promontory at high stimulation rates in Meniere disease ears (MDEs).

Material and methods: Control ears (CEs) and 32 MDEs were tested using an evaluation strategy of the auditory system involving a 'Continuous Loop Averaging Deconvolution' technique (CLAD). Hearing was tested by TT-ECochG with stimulation rates (SR) of 7/s–780/s.

Results: In the CEs, SP/AP ratio reached 1 at SR 600/s, in MDEs at 50–100/s. AP latencies in CEs were increasing till SR 300/s, then were stable, and for SR >500/s were decreasing. For MDEs, latencies increased till SR 250/s, then the latency remained stable.

Conclusions: Very high SRs provide an information about the adaptation processes of the peripheral auditory system in CEs and MDEs. The CLAD strategy supports traditional audiological test battery in diagnosis of typical cochlear auditory pathologies.

Tuesday, May 23rd

Special session I – History of IERASG

Moderator: Roger Thornton

Roger Thornton[1], John D. Durrant[2], Robert Burkard[3], Wanda Bochenek[4]

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[3] *Department of Rehabilitation Science, University at Buffalo; U.S. Navy Marine Mammal Program, Space and Naval Warfare Systems Center Pacific; National Marine Mammal Foundation; National Marine Mammal Foundation, USA*
[4] *Professor Emeritus, Warsaw Medical University, Poland*

Roger will cover the origins of our society, the founding fathers, and the importance of our free, easy and informal standards; followed by a quick tour of the sites of our previous meetings. Then the impact that this society has made over the past and up to the present will be assessed.

John will recall some of his most memorable highlights over the years, the organization of our meetings and the joys and pain encountered when you have to organize a meeting.

Robert will focus on the meetings that he has attended and discuss the presentations and the all-important summaries of our symposia. He will also talk about the central role of our meetings in the creation of the Burkard, Don and Eggermont book.

Wanda will tell us of the origins of ERA and will talk about the development of ERA in Comecon* countries. As one of the pioneers in this field her memories will be valuable and instructive.

The session is designed to demonstrate the informal approach that we take and so expect light-hearted presentations, bad jokes, insults and character defamation.

** The founding of the Council for Mutual Economic Assistance (Comecon) dates from a January 1949 communique agreed upon by the Soviet Union, Bulgaria, Czechoslovakia, Hungary, Poland and Romania in Moscow. In 1971 the Comecon countries adopted the Comprehensive Program for Socialist Economic Integration.*

Otoacoustic emissions and Wideband absorbance

Moderators: George Tavartkiladze, Jacek Smurzynski

Cochlear Echoes: What we really assess with the OAE responses. (An excursus into the realm of clinical OAE applications)

Stavros Hatzopoulos

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Despite the fact that Otoacoustic Emissions (OAEs) have been discovered by David Kemp in the late seventies, the array of possible clinical applications is quite narrow. Currently OAEs are being used primarily in neonatal hearing screening protocols. OAEs being pre-neural responses have a limited potential in assessing higher order auditory structures (brainstem, auditory cortex etc.).

But even in neonatal hearing screening the role of OAEs is not entirely charted. The standardized protocols retrieve information from a small segment (6–12 ms) of the OAE response, neglecting low and high frequency information from the other segments of the OAE recording.

In this lecture, using as a magnifying lens, a time-frequency representation of transiently evoked OAEs (TEOAEs) we will examine the totality of the information presented in the OAE response. Several questions regarding the precision of our NHS practices will also be postulated.

Input/output characteristics of tone burst-evoked otoacoustic emissions

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World Hearing Center, Institute of Physiology and Pathology of Hearing, Warsaw/Kajetany, Poland

Objectives: The purpose of the present study was to investigate input/output (I/O) characteristics of tone burst-evoked otoacoustic emissions (TBOAEs) and compare them with click evoked otoacoustic emissions (CEOAEs).

Material and methods: In group of adults in each ear, a set of measurements were made: CEOAEs, and TBOAEs at frequencies from 0.5 to 4 kHz. For each stimulus type input/output functions were measured for levels from 40 to 90 dB SPL.

Results: The TBOAEs had generally higher levels then CEOAEs and lower detection thresholds. The TBOAEs I/O characteristics had slightly less saturation at higher levels then CEOAEs. However the correlations between CEOAEs and TBOAEs were usually very high.

Conclusions: TBOAEs share many similarities with CEOAEs however they can be especially important when lower detection threshold of the signal is of value.

Variability of Medial Olivo-cochlear Reflex acrros Click- and Distortion Product Evoked Otoacoustic Emissions

Kayla Ichiba, Siena Schoelin, Alireza Pourjavid, Barbara Cone

University of Arizona

Objectives: The purpose of this research was to estimate the strength and stability of the MOCR for click-evoked (CEOAE) and distortion product (DPOAE) otoacoustic emissions in individuals.

Material and methods: We obtained CEOAEs and DPOAEs from 24 females in quiet and with contra-lateral broadband noise at 60 dB SPL. The quiet and contra-noise conditions were repeated 3 times for 2 click-levels and for 65–50 dB DPOAE primaries.

Results: CEOAE and DPOAE amplitudes were reduced in the contralateral noise condition, consistent with the activation of the MOCR. CEOAE-MOCR values were larger than those for DPOAE and less variable. **Conclusions:** Instances of "enhancement" due to MOCR activation were rare. A distinction between subjects who enhance rather than inhibit may be a useful starting point for clinical application.

Comparison of wideband tympanometry results from two devices

Lech Sliwa, Krzysztof Kochanek, Henryk Skarzynski

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Objectives: Wide Band Tympanometry (WBT) is becoming an interesting methods of middle-ear investigation, and commercial devices for WBT are presently available. However, because characteristics of these systems are different, so the test results might differ.

Material and methods: About 40 normal-hearing subjects were examined with the two systems. Before WBT tests, the subjects were subjected to otologic and audiologic examination. The tests were repeated twice alternatively in both ears to verify repeatability.

Results: Mean EA values measured with the two systems differ significantly almost in the whole frequency range. There are no significant differences between EA variances in the two systems. No significant influence of ear and/or gender was found.

Conclusions: EA values measured with different instruments differ significantly. Then, the range of normative values and pathology criteria must be determined individually for each system.

Wideband tympanometry in otosclerotic ears

Elzbieta Niemczyk, Magdalena Lachowska, Kazimierz Niemczyk

Department of Otolaryngology, Medical University of Warsaw, Warsaw, Poland

Objectives: The goal of this study was to evaluate absorbance measurements in otosclerotic ears.

Material and methods: Otosclerosis was confirmed surgically in 54 ears and all 54 ears underwent analysis. Pure tone audiometry, impedance audiometry, wideband tympanometry and absorbance measurements were performed before the surgery.

Results: The analysis of absorbance measurements allowed to distinguish 5 types of absorbance graphs depending on: the number of peaks, the maximum absorption and the width of the graph. All five types of absorbance graphs are discussed.

Conclusions: Incorporating WBT with absorbance measurements in middle ear diagnostics is of great help in detection of otosclerotic ears. This method may provide additional information about severity of otosclerosis.

Wednesday, May 24th

Special session II – Advances in Functional Imaging of the Central Auditory System

Moderators: David L. McPherson[1,3], Tomasz Wolak[2], David Sorensen[3]

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[2] *Bioimaging Research Center, World Hearing Center*
[3] *Neuroscience Center, Brigham Young University*

Functional imaging of sensory systems has produced an exceeding number of advancements over the last decade. Prior to the discovery and implementation of functional magnetic resonance imaging (fMRI) the majority of functional brain activity was done using a variety of special applications of the electroencephalogram; specifically, endogenous sensory evoked or related potentials. This technique produced a plethora of scientific reports on sensory processing. Likewise, the use of fMRI in the analysis of sensory function of brain activity has expanded our knowledge and understanding of sensory systems. More specifically, this technique has expanded our understanding and intricacies of processing within the auditory system, especially higher cortical function.

The intent of this presentation is to give some basic background in advanced techniques of fMRI and quantitative EEG (QEEG). Fundamentals of recording procedure, experimental design, and examples of utilization will be shown. This will include but not limited to multi sensory integration, simultaneous fMRI and evoked potential data collection, imaging techniques, sample size and statistical considerations, as well as processing of language and complex tonal information (tonotopic cortical organization).

ASSR I

Moderators: Andrew Dimitrijevic, Jun-Ho Lee

Multi-Rate Spread Spectrum ASSR

Andre Lodwig

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Objectives: As already presented by T. Rosner in 2013, multi-channel ASSR can be evoked with non-constant stimulus rates. Objective of the presented work was to find optimum stimulus and recording parameters for this "Spread Spectrum ASSR" method.

Material and methods: A simple cochlea model has been applied to various narrow band chirp signals at different center frequencies and repetition rates. Predicted optimum parameters have then be implemented and tested clinically.

Results: Cochlea model simulations show the effects of stimulus frequency, bandwidth and rate and suggest rates of less than 40 to over 160 Hz for stimulating 500 Hz to 8 kHz center frequencies. Model-predicted optimum rates align well with measured data.

Conclusions: Multi-Rate Spread Spectrum ASSR appear to be a powerful implementation of ASSR which very low false detection rates and good correlation to pure tone audiometry.

Improved reliability of binaural multi-frequency ASSR measurements by combining ipsi- and contra-lateral EEG data for automatic response detection

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[2] *Interacoustics Research Unit, Lyngby, Denmark*
[3] *WDH Berlin, Germany*

Objectives: ASSR are well suited for automated response detection. The present study investigates if automatic response detection of the ASSR can be reliably improved by combining measurements from bo.

Material and methods: ASSR raw data were collected from routine clinical measurement in the department of audiology. For automated response detection ipsi- and contra-lateral measurements were combined by averaging responses from both sides.

Results: The contra-lateral ASSR response amplitudes are smaller than ipsi-lateral recordings. The combination of ispi- and contra-lateral ASSR data showed a significant improvement of the detection rates for 500 Hz and 1 kHz while maintaining detection times.

Conclusions: The results showed that combination of ipsi- and contra-lateral ASSR data by averaging can improve the signal-to-noise ratio and with it the detection rates. That might be lead finally to a positive effect in the detection rate and time.

Measurement efficiency of multiple 30–50 Hz ASSRs

Robin Gransier, Astrid van Wieringen, Jan Wouters

ExpORL, Department of Neurosciences, KU Leuven, Leuven, Belgium

Objectives: Binaural interaction can attenuate 30–50 Hz ASSRs when evoked dichotically and thereby reduce the measurement efficiency. The objective of the present study is to gain insight in this interaction effect and how it affects measurement efficiency.

Material and methods: Monaurally and dichotically evoked ASSRs were recorded in twenty-three adults. Amplitude modulated octave-band noise bands were presented at 70 dB. Different modulation frequencies within the 30–50 Hz range were varied across ears and conditions.

Results: Dichotic stimulation resulted in an overall attenuation of the 30–50 Hz ASSRs compared to monaural stimulation. This attenuation resulted in a ~33% reduction in measurement efficiency for modulation frequencies ≥40 Hz.

Conclusions: Our results show that multiple 40–50 Hz ASSRs are as efficient, or more efficient in ~66% of the measurements compared to sequential monaural stimulation.

Multichannel frequency-domain Hotelling's T2 test for detection of envelope following responses to natural vowels

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Institute of Sound and Vibration Research, University of Southampton, United Kingdom

Objectives: A multichannel frequency-domain Hotelling's T2 (MCHT2) method for envelope following response detection is introduced and its sensitivity compared to a Fourier Analyzer (FA), Magnitude Squared Coherence (MSC), and single-channel Hotelling's T2 (HT2).

Material and methods: EEG data were collected from 12 normal hearing adults during auditory stimulation with 4 repeated vowels. Each stimulus was presented 220 times with both polarities. Response detection was compared between algorithms based on detection rate and time.

Results: A five-channel MCHT2 showed a significantly higher detection rate compared to FA (27% increase) and MSC (24%) detection rates. Both HT2 and MCHT2 showed a significant decrease in mean detection time compared to the FA (29% and 39%, respectively).

Conclusions: MCHT2 analysis improves sensitivity in the detection of envelope following responses to natural vowels compared to single-channel methods, without increasing computational complication.

ASSR II

Moderators: David Purcell, W. Wiktor Jedrzejczak

Binaural loudness balancing using auditory steady-state responses

Maaike Van Eeckhoutte, Jan Wouters, Tom Francart

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Objectives: In contrast to asymmetric hearing (AH), normal-hearing (NH) listeners perceive balanced loudness at both ears, leading to good sound source localization skills. We aimed to objectively measure binaural balanced loudness in case of AH.

Material and methods: We tested NH and AH listeners in two tasks: 1) EEG was recorded to the stimuli presented monaurally at different intensities to obtain 40-Hz ASSR amplitude growth of both ears, and 2) behavioral binaural loudness balancing was performed.

Results: For NH listeners, who have equal loudness growth across the ears, the difference between the left and right ear 40-Hz ASSR amplitude growth was small. For listeners with an AHL, similar ASSR amplitudes were found corresponding to similar loudness.

Conclusions: This demonstrates the potential of using 40-Hz ASSRs to objectively find the binaural balanced loudness for fitting in case of AH. Such an objective measure can contribute to more automatic and objective fitting of hearing aids.

Exploring the encoding of sound level in the speech-evoked frequency following response to four synthetic English vowels

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[1] *School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa, Canada*
[2] *School of Electrical Engineering and Computer Science, University of Ottawa, Canada*

Objectives: To study level effects in the encoding of four vowels in normal hearing adults using the envelope and spectral frequency following response (eFFR and sFFR). We hypothesized that F0, F1 and their neighboring harmonics would grow with increasing level.

Material and methods: 19 subjects (8F, 11M, 20–35 yrs) were recorded with four 100 ms vowel stimuli with F0=100 Hz (F1: /a/=700 Hz, /e/=600 Hz,/ɔ/=500 Hz,/u/=300 Hz) at four levels (55, 65, 75, and 85 dBA). eFFR and sFFR spectral amplitudes for each vowel and level were analyzed.

Results: Significant effects of level exist at F0 in the eFFR and F1 in the sFFR ($p<0.01$ in all cases). The combined harmonics show effects of level ($p<0.001$ in all cases), as well as significant pairwise comparisons between most levels.

Conclusions: Effects of level exist in the encoding of the speech eFFR and sFFR. The eFFR shows increasing spectral richness via the growth of the harmonics of F0 but not at F0 itself, while the sFFR shows a pattern of growth at F1 and its neighboring harmonics.

EASSRs for characterizing across-channel variability in cochlear implants

Jan Wouters, Robin Gransier, Robert Luke, Astrid van Wieringen

ExpORL, Department of Neurosciences, KU Leuven, Leuven, Belgium

Objectives: To gain insight in the electrode-neuron-interface (ENI) in cochlear implants using electrically evoked auditory steady-state responses (EASSRs), and investigate the variation in ENI across stimulation channels as a marker for speech intelligibility.

Material and methods: EASSRs were recorded in ten adult CI users using a 64-channel EEG setup. Monopolar stimuli at 500 pps and modulated at 40 Hz, were presented at comfort level. EASSRs were compared with different channel specific behavioral measures.

Results: The results show subject dependent across-channel EASSR variations which are not directly reflected in most behavioral metrics, and a composite measure of variation across channels is significantly related to speech recognition.

Conclusions: ASSRs provide a measure for characterizing the electrode-neuron interface in cochlear implants based on modulation transfer, and this measure is related to speech intelligibility

Auditory steady-state response (ASSR) modulation-rate transfer functions (MRTFs) of the bottlenose dolphin to SAM tones, tonebursts and clicks

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Objectives: This study assesses whether the differences between the ASSR MRTF (i.e., extending above 1000 Hz) and ABR rate-amplitude functions (i.e., rolling off above 100–200 Hz) in dolphins is due to the different stimuli used to elicit these responses.

Material and methods: ASSR MRTFs (100–5000 Hz) to SAM tones (40 kHz), tonebursts (40 kHz) and clicks were obtained at a fixed level (145 dB peSPL) and MRTFs were compared across stimuli for five bottlenose dolphins (2 normal hearing: NH, 3 hearing-impaired: HI).

Results: ASSR amplitudes were smallest for SAM tones. ASSR amplitudes were largest at 500–1000 Hz, and dropped off abruptly above 1000 Hz, both for NH and HI dolphins. ASSR amplitudes were larger to clicks than tonebursts in NH, but not HI, dolphins.

Conclusions: The extended upper-cutoff frequency (1000 Hz) of the dolphin MRTF compared to the drop in ABR amplitude at click rates above 100 Hz appears to be related to the spectral peaks of the ABR near 500 and 1000 Hz, and the resulting ABR peak overlap.

Middle and long latency responses

Moderators: Suzanne C. Purdy, Frank E. Musiek

Employing the acoustic change complex for vowel discrimination

Barbara Cone, Diane Cheek

University of Arizona

Objectives: The present study in adults addressed the effects of level and vowel contrast type on ACC amplitudes and latencies and the comparison of ACCs in adults to infants (Cone, 2015).

Material and methods: Nineteen normal-hearing adults were tested with vowel tokens, /a,i,o,u/ of 500 ms duration presented at 2/s, at 40 and 70 dBA in the sound-field.

Results: ACC amplitudes were significantly larger at 70 dBA but latencies unaffected by level. ACC amplitudes varied with vowel pair. ACC amplitudes for contrast conditions were 4–6 times larger than in control conditions.

Conclusions: The ACC for vowel contrasts are robust even at low levels i.e., 25–30 dB SL. There was a significant effect of second formant magnitude and direction change, confirming ACC's sensitivity as a measure of vowel discrimination.

Using Cortical Evoked Potentials to Predict Speech Feature Perception in Infants

Barbara Cone, Spencer Smith, Diane Cheek

University of Arizona

Objectives: The specific aim was to evaluate the effect of stimulus rate on cortical auditory evoked potentials (CAEP) evoked by a change in vowel type when presented in an odd-ball paradigm.

Material and methods: 26 normally hearing infants (age mean=5.6 months) were tested using synthesized vowels tokens presented at rates of 1- and 2/s in an odd-ball paradigm. CAEPs were measured for each token when used either as a 75%-standard or as a 25%-deviant.

Results: Contrasts at the 2/s rate evoked responses that were up to 8 times larger than response to controls, whereas those for the 1/s rate were not always distinguishable from control conditions.

Conclusions: These results exemplify the promise of the ACC for indicating perception of vowel differences in infants that could be used in the fine-tuning of hearing aids and cochlear implants.

Reduction of cochlear implant artefacts in single-channel cortical auditory evoked potentials (CAEPs) recorded to 400-ms narrowband noise stimuli in the free field

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Objectives: The aim of this study was to evaluate whether a single-channel cortical auditory evoked potential (CAEP) recording system could be used for clinical testing with cochlear implant (CI) users.

Material and methods: Narrowband noise stimuli were presented in the free field from –10 to 40 dB sensation level to record CAEPs in 9 adult Cochlear CI users to derive an electrophysiological detection threshold.

Results: – CAEP presence increased for 400-ms stimuli when compared to using shorter stimuli; – CI artefacts could be reduced through advanced signal processing; and- these interventions seem to facilitate (CI aided) CAEP hearing threshold estimation.

Conclusions: These results are a preliminary step towards threshold estimation on directly stimulated CI electrodes, aiding with the objective fitting of CIs in the clinic.

Changes in Stimuli Spectral Complexity Modulates Cortical Auditory Evoked Potentials Amplitude

Bardy Fabrice, Lee Chelsea, Van Dun Bram, Dillon Harvey

National Acoustic Laboratories, NSW, Australia

Objectives: The aim was to explore the effects of changing the spectral characteristics of the auditory stimulus on the CAEP amplitude. Both the spacing between frequency components and the number of components present in one frequency space were investigated.

Material and methods: We recorded CAEPs from 15 normal-hearing adults in response to a pure-tone and multitone (MT) stimuli. The MTs were created by combining 2 to 9 sinusoids located in either 2 or 3 equivalent rectangular bandwidths (ERBs).

Results: Our results indicated that the CAEP amplitude was affected by both the frequency separation of the auditory components and the number of components. The largest amplitude was observed for MTs composed of 2 or 3 sinusoids located in 3 ERBs.

Conclusions: Optimization of neural responses has potential application for future clinical practices as a larger neural response to frequency specific stimuli can allow a testing time reduction.

Evaluation of Deep Neural Networks for Cortical Auditory Evoked Potential (CAEP) Detection

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Objectives: The aim of this study was to evaluate the performance of deep neural network (DNN) classifiers for the detection of CAEPs.

Material and methods: CAEPs were recorded from 63 adults in response to short acoustic stimuli and used as training data. The performance of the DNNs was evaluated on a test data set comprised of 47 adults.

Results: The performance in terms of classification accuracy of CAEPs for several feature extraction methods and DNN architectures will be presented and compared to the Hotelling's T2 statistic.

Conclusions: Improving the detection of CAEPs by using DNNs could allow both a reduction of testing time and better estimation of hearing thresholds which would be beneficial for clinical practice.

Auditory Evoked Potentials Generated by Noise Gaps: Effects of Onset, Offset and Duration

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Objectives: Composite nature of Auditory evoked Potentials (AEPs) generated by wide-band noise gaps at slow rates (1 Hz) is investigated by recording different gap duration responses and convolution simulations of onset and offset responses.

Material and methods: In this study 10 noise gaps with varying durations (6 ms to 300 ms) are studied using monaural stimulation recorded with continuous recording of EEG at a high sampling rate (5 kHz). Recordings are averaged off-line and digitally filtered for analysis.

Results: Long gaps evoke distinct onset and offset AEPs. For medium gaps responses become smaller with unidentifiable peaks. The largest AEPs are generated by 25 ms gaps. Shorter gaps produce small waves with distinct V, Pa, Pb peaks.

Conclusions: Gap AEPs are generated by gap onset and offset responses and can be modeled by their destructive (medium duration) and constructive (short duration) overlap modified with adaptation and masking effects.

Speech-evoked cortical auditory evoked potentials in adults with mild cognitive impairment compared to younger and age-matched controls

Suzanne C. Purdy[1,2], Oscar Canete[1,2], Joan Leung[1,2], Abin Kuruvilla-Mathew[1], Peter R. Thorne[2,3], Lynette Tippett[1]

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[2] *Eisdell Moore Centre for Research in Hearing and Balance*
[3] *Audiology, Faculty of Medical and Health Sciences*

Objectives: Hearing thresholds, self-reported listening difficulties and cortical auditory evoked potentials (CAEPs) were obtained in people with mild cognitive impairment (MCI) and compared to age-matched and younger controls with no cognitive impairment.

Material and methods: Cognition was assessed using MoCA scores. Hearing difficulties were assessed using the Speech, Spatial and Qualities (SSQ) questionnaire. P1-N1-P2 latencies/amplitudes were recorded at Fz and Cz to /di/ and /gi/ and compared between groups.

Results: SSQ scores indicated greater listening difficulties in MCI and /gi/-evoked P2 amplitudes differed between MCI and age-matched controls. P2 latencies and some amplitudes differed between older and younger controls, as did hearing thresholds.

Conclusions: Central auditory (CAEP) changes and greater reported listening difficulties were found in people with MCI, consistent with evidence for cognitive impairment reflecting changes in brain structures or brain ageing that also affects auditory areas.

Cortical detection of stimuli presented from different angles: The /"Spatial Change Complex/"

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Objectives: Besides behavioral tests, spatial perception can also be assessed with electrophysiological techniques like MMN (see MMN paper, IERASG2015). To question is whether, analogous to ACC, it is possible to use SVPs to assess different angles perception.

Material and methods: Spatial perception was assessed using broadband noise stimuli with intra-stimulus spatial change of ±30 and ±90 degrees. Additionally, subjective responses, but also recordings were repeated with unilateral ear plugging.

Results: EEG shows new cortical EPs ('spatial change complex') at different angles. In earplugged condition, SCC was still recognized, but not statistically significant, assuming disturbed perception in conformity with behavioural responses.

Conclusions: It is possible to obtain auditory cortical responses reflecting the perception of spatial changes in the sound field, simpler and faster than MMN, that can be used as a measure for detection of spatial changes within a stimulus.

Auditory Evoked Potentials in Cochlear Implant Users

Moderators: Andy Beynon, Artur Lorens

Recordings of acoustic evoked potentials directly from the cochlea via intracochlear electrodes in partially deafened cochlear implantees

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Objectives: Nowadays patients with Partial Deafness, with certain degree of hearing preservation receive cochlear implantation. For this group it is possible to record acoustically evoked evoked response directly from the cochlea using implant electrode.

Material and methods: 50 implanted adults participated in study. They use Pulsar, Sonata, Concerto or Synchrony. Acoustical stimuli were presented to implanted ear. Synergy system was used for stimulation. Responses were recorded from CI electrode using MAX interface.

Results: Responses for all frequencies were obtained for 37 of 50 patients.

Conclusions: Presented results show possibility of acoustically evoked responses from the cochlea using CI electrode.

Auditory neuroplasticitic change of cochlear implant recipients revealed in cortical auditory evoked potential

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Objectives: P1 CAEP is known as a biomarker for development of the human central auditory pathway. The aim of this study was to examine the P1 CAEP latency in patients with cochlear implants (CIs) as a function of the duration of deafness and that of CI use.

Material and methods: P1 CAEPs were recorded in 22 postlingually-deafened adults and 16 preligually-deafened children after cochlear implantation. The correlation between the latency of P1 CAEP and the duration of deafness or the duration of CI use were analysed.

Results: Adult CI recipients with present P1 CAEP (n=11) had significantly shorter deaf duration than those with absent P1 CAEP (n=11) (p=0.01). There was a negative correlation between the P1 latency and the duration of CI use (r=–0.91, p=0.001) in children.

Conclusions: P1 CAEP latency was correlated with the duration of deafness in adults, and with that of CI use in children. This may imply that a neuroplasticitic change occurs as a results of auditory deprivation or electrical stimulation.

Epidural Recordings of Auditory Evoked Potentials in Cochlear Implant Users

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[2] Neuropsychology, Carl-von-Ossietzky-University of Oldenburg
[3] Cluster of Excellence Hearing[4]All

Objectives: On the long term it is desirable for CI users to control their device in a closed loop via brain signals. In an everyday life application the use of implanted recording electrodes is convenient, also a better signal quality can be expected.

Material and methods: In this study we investigate the feasibility of implanting epidural electrodes temporally during CI sur-gery and the possibility to record AEPs in the course of several days when the patient is awake again. After some days the electrodes are removed.

Results: First data sets of 8 patients were obtained showing promising results. The recorded potentials were compared to clinical standard recordings. Especially the CERA depicted clearer N100 waves which were also visible at lower stimulation intensities.

Conclusions: Altogether the approach is feasible, safe and well tolerated by the patients, and the AEP waves are clearly recognizable.

Cortical auditory evoked potential is modulated by attention and related to speech perception abilities in cochlear Implant users

Ji-Hye Han, Andrew Dimitrijevic

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Objectives: In this study, we examined the neural processes underlying SiN perception using categorical /ba/-/pa/ voice onset time continuum in noise while CI users were actively engaged in a consonant-vowel discrimination task.

Material and methods: Ten adult CI users and fourteen normal hearing controls participated. Speech stimuli were synthesized CVs from a 6-step VOT /ba/-/pa/ continuum. N1, P2, and P3 amplitudes and latencies were analyzed as a function of VOT and listening condition.

Results: The N1 and P2 latencies in the attended condition increased with increases in VOT. Slope of N1 latency were greater in good versus poor CI users and NH. The P2 amplitude and latency change was correlated with consonant and word perception in noise.

Conclusions: Good CI users exert greater top-down modulation of the N1 latency compared to NH and poor performing CI users. P2 responses appear to have a better overall relationship to speech perception in CI users compared to N1.

Thursday, May 25th

Protocols and procedures in evoked potential measurements

Moderators: Robert Burkard, James W. Hall III

Frequency-specificity using belly-tendon montage to obtain Ocular Vestibular Evoked Myogenic Potentials

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Objectives: Ocular Vestibular Evoked Myogenic Potentials (oVEMPs) are usually acquired with standard suborbital electrode montage. Alternatively, belly-tendon montage is hypothesized to yield larger response amplitudes than standard montage.

Material and methods: 2 experiments: first, oVEMP amplitudes, latencies and thresholds acquired with either standard or belly-tendon montage are compared using a 500 Hz tone burst, using MiniShaker. Second, responses to 250, 500, 750, 1000 Hz tone bursts were compared.

Results: Belly-tendon montage show larger response amplitudes and lower thresholds than standard clinical montage. With respect to the frequencies, data show that the 500 Hz stimulus evokes the highest response rate and amplitudes for healthy subjects.

Conclusions: High-level MiniShaker stimulation by bone conduction reveal better oVEMP responses with belly-tendon montage. Responses depend on frequency of tone burst stimulation. Normative data is presented.

A fully automatic method for removal of artifacts from EEG

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Objectives: To develop an unsupervised EEG preprocessing scheme to fully automatically remove artifacts. The performance is compared with Independent Component Analysis (ICA), the current state of the art, which requires manual selection of artifact components.

Material and methods: A multi-channel Wiener filter (MWF) and ICA are applied to an EEG dataset from which the envelope of natural running speech is reconstructed. The correlation between original and reconstructed envelope is related to speech intelligibility.

Results: When applying the decoder after artifact removal with the MWF, 91% of the correlations increased compared to the unfiltered data (ICA: 71%), with an average increase of 0.024 (ICA: 0.019), which is a relative improvement of 16% (ICA: 12%).

Conclusions: We presented a novel method for artifact suppression, which outperformed ICA and has the additional advantage of being unsupervised. The use of this filter as an EEG preprocessing step can improve detection of auditory evoked responses.

Effects of recreational noise on evoked potential amplitude and other auditory test metrics

Colleen G. Le Prell, Sarah K. Grinn, Jason Baker, Kathryn Wiseman

School of Behavioral and Brain Sciences, University of Texas at Dallas, USA

Objectives: This study had two objectives. First, baseline audiometric data was assessed for associations with noise exposure history. Seconds, subjects were followed prospectively to assess potential auditory effects of new loud recreational activities.

Material and methods: Testing included tympanometry, pure-tone and speech reception thresholds, word-in-noise tests, and ABR and DPOAE measurements. All tests were completed at baseline, and repeated the day after a "loud" recreational event and one week later.

Results: There was no reliable relationship between recreational noise history and auditory test metrics. After acute event exposures, a variety of dose-dependent temporary changes were observed across metrics. Final tests one week later showed recovery.

Conclusions: Recreational noise was not correlated with chronic or acute changes in function or evoked potential amplitude. However, two subjects with 16-hr exposures had changes in function, indicating hazardous exposures for which hearing protection was needed.

Synaptopathy with envelope frequency responses (EFR): The off-frequency problem

Gerard Encina-Llamas[1], Aravind Parthasarathy[2], James M. Harte[3], Torsten Dau[1], Sharon Kujawa[2], Barbara Shinn-Cunningham[4], Bastian Epp[1]

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Objectives: An AN computational model was used to investigate the effects of off-frequency contributions and the differential loss of different AN fiber types on EFR

level-growth functions, and was compared to EFR level-growth in humans and mice.

Material and methods: EFR level-growth functions (40–90 dB SPL) were recorded in humans and mice using SAM tones at m=25 and 85%. A humanized AN model (Zilany et al., 2014) was used to simulate the EFR level-growth functions for several degrees of synapatopathy.

Results: The AN model can account for the trends obtained from human EFR level-growth functions. The total EFR responses are strongly dominated by the high-SR fibers. The simulated EFR level-growth functions agree well with EFR functions recorded in mice.

Conclusions: Off-frequency contributions of high-SR fibers dominate the total model EFR responses. Loss of low- and medium-SR fibers has little impact on measured EFRs. The simulated EFR level-growth functions are in close agreement to the ones recorded in mice.

Cognitive and event-related potentials

Moderators: Robert Cowan, Mridula Sharma

The effect of noise on N400

Shivali Appaiah Konganda[1,2], Mridula Sharma[1,2], Joaquin Tomas Valderrama Valenzuela[1,2,3], Elizabeth Beach[2,3], Jessica Monaghan[1], John Newall[1], Gitte Keidsar[2,3], Elaine Schmidt[4]

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Objectives: To evaluate the morphology of the N400 event related potential (ERP) at different signal-to-noise ratios (SNRs).

Material and methods: The N400 ERP was recorded from 8 subjects with normal hearing using 64 EEG channels. Semantically congruent and incongruent sentences at 65 dB SPL were presented in quiet, +10 dB SNR and +5 dB SNR.

Results: Visual and statistical analysis of the signals show a clear N400 in the quiet and +10 dB SNR. However, at +10 dB SNR the area under the curve is reduced compared to the quiet scenario. At +5 dB SNR, the N400 ERP is not visually evident.

Conclusions: The list of sentences used in this study is efficient to elicit the N400 ERP. In addition, this study shows for the first time N400 ERPs elicited in noise, thus providing a reference of this ERP at different SNRs.

EEG alpha rhythms as a biomarker for Listening Effort for speech in noise perception in cochlear implant users

Andrew Dimitrijevic

Sunnybrook Health Science Centre Cochlear Inmplant Program; Department of Otolaryngology – Head and Neck Surgery; Faculty of Medicine, University of Toronto, Canada

Objectives: Cochlear implant (CI) users struggle listening in adverse environments and often report that they exert tremendous listening effort (LE) understanding speech in noise (SiN). In this study we related LE to EEG alpha in CI users while listening SiN.

Material and methods: Ten adult CI users were tested in free field using their everyday CI setting while performing the Digit Triplet Test (DTT). 64 channel EEG recordings were made during DTT listening and were asked to rank the LE during the task.

Results: Listening to SiN was associated with increased alpha power. Significant correlations were observed between left frontal alpha power and LE in CI users using brain source analysis.

Conclusions: Given that alpha power was significantly correlated to LE and that CI users had greater alpha power compared to normal hearing individuals, alpha may represent an objective measure of LE in CI users.

The relationship between 3-Month-Old Speech Contrast MMN and Performance on Behavioral Measure of Speech Discrimination at 7 Months of Age

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Objectives: To examine an objective measure of speech discrimination that may later be used to assess the goodness of hearing aid fit in these infants.

Material and methods: MMN and CHT in normal hearing infants (n=33) for the same vowel and consonant-vowel speech contrasts. Computed MMN using normalized eigenspectrum and weights for each contrast and infant. Explored clinical utility in 10 infants with HA.

Results: Linear fits showed within-subject and contrast relationship between 3 month MMN and CHT discrimination at 7 months. Infants showed MMN change with HA versus without. Preliminary group results in infants with HA suggest similar trend to NH infants.

Conclusions: These findings demonstrate the feasibility of MMN as a measure of infant speech discrimination and as a potential tool for assessing HA fit.

Behavioral and online statistical learning in children with musical training

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Objectives: Objective: Statistical learning (SL) is an implicit ability to extract statistical cues from continuous stream of stimuli. This study compared behavioural and online (electrophysiological) measures of SL in children with and without musical training.

Material and methods: SL of regularities embedded in auditory and visual stimuli was measured in musically trained and age-matched untrained children (9–11 years). ERPs were recorded as children listened to pure tones or watched cartoon figures.

Results: Grand-averaged ERPs showed that initial stimulus elicited larger responses in the musically trained children for both auditory and visual online tasks. Music skills were associated with performance on auditory and visual SL tasks.

Conclusions: Our data suggests that auditory skills such as rhythm perception might facilitate detection of regularities in children.

Effect of spectral resolution on neural entrainment of the speech envelope

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Objectives: Research shows that neural entrainment of the speech envelope correlates with speech understanding. While keeping the envelope fixed we investigated the effect of spectral resolution on neural entrainment, thus varying speech intelligibility.

Material and methods: Nine normal-hearing subjects listened to vocoded speech in quiet and noise while the EEG was recorded. We estimated neural entrainment by correlating the actual speech envelope with the one decoded from the EEG.

Results: We found an increase in neural entrainment when more vocoder bands were used, indicating that spectral distortion can have measurable effects on speech envelope based methods. These results correlate with behaviorally measured speech intelligibility.

Conclusions: Even though our neural entrainment measure only depends on the speech envelope, we can still see an effect of spectral resolution, indicating that it is not merely a measure of coding of the envelope, but also relates to speech understanding.

Evaluating auditory discrimination in infants using visual reinforcement infant speech discrimination (VRISD) and the acoustic change complex (ACC)

Robert Cowan[1,2], Teresa Ching[1,3], Bram Van Dun[1,3], Vicky Zhang[1,3], Cara Wong[1,3], Fabrice Bardy[1,3], Mridula Sharma[1,4], Gary Rance[1,2,5], Donella Chisari[1,2,5], Julien Zanin[1,5], Trish Van Buynder[3,6], Lauren Burns[3,6], Laura Button[3,6], Nan Xu[1,4], Katherine Demuth[1,4], Harvey Dillon[1,3,4]

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[6] *Australian Hearing, Sydney, Australia*

Objectives: The study's goal is to test 60 hearing-impaired and 30 normal-hearing infants, both with ACC and behavioural VRISD tests at an age of 3–12 months, and correlate these data with their language ability at 3 years of age.

Material and methods: The ACC to 3 contrasts were recorded in the free field at 20 sones (65~70 dB SPL). The stimuli consisted of a spectral-ripple noise (SRN), sibilants /s-z/ and vowels /u-i/. In addition, a VRISD procedure was conducted using /s-sh/, /s-z/ and /u-i/.

Results: ACC detection sensitivities in 43 hearing-impaired [22 normal-hearing] infants (<12 months) to SRN, /s-z/ and /u-i/ contrasts were 49 [65], 61 [83] and 84 [94]%, respectively (specificity >90%). VRISD results were poor in both groups (<50% passed).

Conclusions: These initial results indicate the ACC could be used to discern between groups, a gradient is present re detection sensitivities, and ACC might be preferred over VRISD for discrimination evaluation.

Electrophysiological and behavioral measures of some speech contrasts in attention and noise conditions

David Jackson Morris, John Tondering

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Objectives: This paper investigates how upregulation of cortical responses, measured in two attention conditions, affects the representation of voice onset time (VOT), place of articulation and vowel length.

Material and methods: Normal hearing subjects (n=20) completed EEG testing in 2 attention conditions, and behavioural testing with stimuli, which were [b̥a(ː)], [pʰa(ː)], [g̊a(ː)] and [kʰa(ː)]. Syllable identification was performed in quiet, 0, 4 and 8 dB SNR.

Results: Feature-specific ERP and global field potentials were compared with the behavioral results. No correlations

between electrophysiological and behavioural measures were found, except between the attention difference for VOT and 0 dB SNR.

Conclusions: These results corroborate previous work showing that VOT is a pervasive feature of the late-latency response that may be linked to speech-in-noise perception.

A new objective test of speech perception in noise: Brain oscillations while watching/ listening naturalistic stimuli.

Andrew Dimitrijevic

Sunnybrook Health Science Centre Cochlear Inmplant Program; Department of Otolaryngology – Head and Neck Surgery; Faculty of Medicine, University of Toronto, Canada

Objectives: One concern in the general population is difficulty following a conversation in a noiseThis study describes a new paradigm that examines sensory and cognitive processing while participants watched/listened to a natural stimulus a TV show.

Material and methods: The Office TV show was played while the 64 channel EEG was recorded. The acoustic output digitized synchronously with the EEG. The brain-audio envelope coherence and alpha/beta was assessed.

Results: Significant coherence between the sound envelope and auditory cortex was observed. The strength of this coherence increased with increasing signal to noise ratio of the sound in the movie. Non-phase locked alpha was observed in parietal regions.

Conclusions: These results demonstrate that the method of using "natural stimuli" can yield robust neural responses that represent both sensory and cognitive processing requiring minimal effort/cooperation from the participant.

Poster Session I

Monday, May 22nd

Methylprednisolone use during radiotherapy extenuates hearing loss in patients with nasopharyngeal carcinoma

Junming Chen, Yuanxin Zhao, Xiaowei Zhou, Lingmei Tan, Zeying Ou, Youjun Yu, Yuejian Wang

The First People's Hospital of Foshan

Objectives: To investigate the hearing protective effects of methylprednisolone use during radiotherapy in patients with nasopharyngeal carcinoma.

Material and methods: 25 patients received radiotherapy with intravenous methylprednisolone for 14 days, and another 28 patients received radiotherapy alone. Distortion product otoacoustic emission and auditory brainstem responses results were reviewed.

Results: The DPOAE levels decreased in the control group. There was no difference in the ABR wave I, III, V latencies and I–V interwave latencies before and one year after radiotherapy.The DPOAE levels increased in the treatment group.

Conclusions: Early sensorineural hearing loss after radiotherapy primarily affected the outer hair cells. The use of methylprednisolone during radiotherapy can extenuate early sensorineural hearing loss caused by irradiation.

ABR wave I presence as an alternative to masking: Do Narrow-Band CE-Chirps® offer an advantage over tone pips?

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Objectives: Presence of wave I in Auditory Brainstem Responses (ABR) can help decide which cochlea was the source. Questions: In what proportion of ABRs evoked by stimuli close to threshold is wave I seen. Is this greater for NB CE-chirps than tone pips?

Material and methods: Near-threshold air conduction (AC) and bone conduction (BC) ABR waveforms evoked by tone pip or NB CE-chirp stimuli, used for earlier comparison studies, were interrogated and criteria developed to judge the presence of wave I in the ABR response.

Results: Using chirps, wave I was present in: 81% of 4 kHz AC, 71% of 4 kHz BC and 57% of 2 kHz AC responses at sensation levels of ≤10 dB. Using tone pips, wave I was present in: 76%, 43% and 10% respectively. Wave I was rarely seen for other test conditions.

Conclusions: Near-threshold chirp ABRs were more likely to contain an identifiable wave I than tone pip ABRs at 4 kHz and 2 kHz providing ear-specific information without the need to mask. Note of caution: masking is needed when wave I is absent or is equivocal.

Comparison of Auditory Brainstem Evoked Responses Results According to the Presence of Diabetes Mellitus in Patients with Tinnitus

Sang Hun Lee, Joong Ho Ahn

Department of Otolaryngology, University of Ulsan College of Medicine, Asan Medical Center

Objectives: The objective of this study was to compare the auditory brainstem evoked responses (ABR) results according to the presence of DM in patients with tinnitus.

Material and methods: Cross-sectional comparative study conducted from January 2014 to January 2016. The study included two groups, (i) tinnitus with diabetes (n=36) (ii) tinnitus without diabetes (n=36).

Results: The mean value of wave I, III, V and the interpeak latencies of III–V and I–V of diabetes group were statistically delayed than those of no diabetes group (p-value <0.05).

Conclusions: ABR is a simple noninvasive procedure to detect early impairment of acoustic nerves. Prolongation of latency of ABR in tinnitus patients with DM should alert us to possible damage to the auditory nerve.

Auditory brainstem responses as an evaluation method for hidden hearing loss in noise-exposed ears with normal audiograms

Kyung Jin Roh[1], Ju Young Kim[2], Min Seok Kim[2], Ji Hyung Kim[2], Seong Ah Hong[2], Seon Geum Kim[2], Eun Jin Son[2]

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[2] Department of Otorhinolaryngology, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Korea

Objectives: The concept of hidden hearing loss can explain the discrepancy between a listener's perception of hearing ability and hearing evaluation using pure tone audiograms. We investigated waveforms of ABR in noise-exposed ears with normal audiograms.

Material and methods: Retrospective review of 42 consecutive patients with noise exposure history.Hearing thresholds were within normal limits in PTA. Wave I and V amplitudes were measured from ABR using click stimuli at 90 dB SPL and compared with normal subjects.

Results: Wave I amplitudes were significantly smaller in noise exposed ears compared control (P=0.003). However,

wave V amplitudes and ratio wave I/V amplitudes were not significantly different (P=0.11 and P=0.095).

Conclusions: The results showed that wave I of ABR using suprathreshold stimuli was smaller for ears with normal audiograms after noise exposure, which may reflect partial loss of auditory nerve fibers.

Bone Conduction Auditory Brainstem Response Measurements with the New Audiometric Bone Conduction Transducer Radioear B81

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Objectives: Bone conduction ABR recordings obtained by the newly designed B81 are compared to that of Radioear B71 to evaluate whether the new transducer principle and motor unit of the B81 would affect ABR magnitudes, latencies, or electrical artifacts.

Material and methods: Electrical input to the B81 is calibrated to achieve the same peak-to-peak vibration amplitude as the B71. ABR to 500 Hz, 2 kHz, and 4 kHz brief tones, click, and chirp at 50 and 20 dB nHL are recorded from normal hearing adults.

Results: The preliminary results obtained indicate similar ABR waveforms obtained by the two bone conduction transducers for the auditory stimuli used in the study.

Conclusions: The new B81 bone conduction transducer appear to provide bone conduction auditory brainstem responses comparable to that of the B71.

Development of novel criteria models for the prediction of acoustic tumor using click and Chirp-evoked ABR

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Objectives: The objective of this study was to develop the criteria models for predicting acoustic tumor using click and level-specific (LS) Chirp-evoked ABR.

Material and methods: 64 subjects with or without acoustic tumor underwent click and LS-Chirp-evoked ABR. Univariate and multivariate analyses were performed with test age, gender, PTA thresholds and wave V amplitudes and latencies of click and LS-Chirp-evoked ABR.

Results: Based on multivariate analyses, two criteria models were constructed. The AUC values, sensitivity and specificity of the model using LS-Chirp and click-evoked ABR were 0.883, 87.5%, 84.4% and 0.860, 71.9%, 90.6% respectively.

Conclusions: Results showed the possibility that these criteria models could serve as screening tools for acoustic tumor. Further study is required to reveal this possibility in the future.

Comparison of Latency and Amplitude of Intraoperative EABR Measurements Between Infants and the Elderly

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Objectives: We compare the latency and amplitude of intraoperative EABR measurements between five infant and four elderly subjects, with the aim of determining whether aging affects the inner ear, the brainstem auditory pathway, or the auditory cortex.

Material and methods: EABR measurements were conducted after insertion of the implant under anaesthesia. Stimuli were delivered at 400, 300, and 200 CU/75 μs. We obtained the latency and amplitude for the wave V created under stimulation of the electrode #7 (middle turn).

Results: For electrodes installed at both the mastoid and the nape, there was no difference in latency between the elderly and infants, but we could see a tendency for the amplitudes of the elderly to be greater than those of the infants.

Conclusions: Using EABR, we couldn't observe any change due to aging or development in the auditory pathway of the brainstem. The cause for waveV of the elderly exhibiting either a normal, a prolonged latency, or no response in ABR is a disorder of the inner ear.

The effect of aging and the high-frequency auditory threshold on speech-evoked mismatch negativity in a noisy background

Junming Chen, Suijun Chen, Yiqing Zheng, Yongkang Ou

Department of Otolaryngology

Objectives: To evaluate the effect of aging and high frequency hearing loss on speech-related mismatch negativity in noisy backgrounds.The possible mechanisms of central auditory processing dysfunction in the elderly were investigated.

Material and methods: 50 people aged 61–80 years old and 50 younger adults aged 21–40 years old were recruited. A Speech discrimination score (SDS) and a speech-evoked MMN under white noise were recorded.

Results: Speech-evoked MMN latency was longer in the aged group. SDS and speech-evoked MMN latency were negatively correlated. Age and speech-evoked MMN latency were positively correlated, as were the pure-tone hearing thresholds and speech-evoked MMN.

Conclusions: In elderly subjects, the function of pre-attentive central auditory processing changes. Increasing age and high-frequency hearing thresholds create weakened synergy in neurons, which may be a cause of central auditory processing disorders in elderly.

An overview on the relationship between the auditory late latency responses in adults with a cochlear implant and auditory performances

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Objectives: The study aims to give an overview on the relationship between the auditory late latency responses in adults with a cochlear implant (CI) and auditory performances.

Material and methods: The overview relies on an extensive literature investigation, including the following topics: set up, recording and interpretation of event-related potentials (ERPs) in CI users and the relationship between the ERPs and the auditory performances.

Results: Cortical reorganization appears when hearing is partly restored by cochlear implantation. Auditory ERPs provide insight into the correlation between the amount of cortical reorganization and CI users' performances.

Conclusions: Final conclusions will be presented at IEAR-ASG 2017.

Cortical Auditory Evoked Responses of Vocal Emotion in Elderly

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Objectives: The present study aimed to evaluate cortical auditory responses of old listeners who have decreased cognitive function compared to young counterparts and to analyze their dependency on vocal emotion.

Material and methods: Twenty old listeners with normal hearing were conducted for a combination of 12 stimulus conditions (three vowels, /a, u, i/ and four emotions, e.g., neutral, sad, happy, angry) to obtain their cortical auditory evoked responses (CAER).

Results: There was a significant difference of P1 and N1 latencies and P1 and N2 amplitudes on emotional aspect, while providing longer latency in sad and larger amplitude in happy. However only /a/ vowel showed significantly longer N1 latency than /u/ vowel.

Conclusions: CAERs reflect clear emotional patterns and less acoustic features for old listeners. This pattern may indicate an early task-specific emotion-based influence on the cognition and apply for aural rehabilitation of the old population.

Cortical Responses elicited by /u/, /a/, /i/ According to Angry, Happy, Sad Emotions

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Objectives: The purpose of this study was to identify how components of CAEP were affected by vowels and emotions. We hypothesized that the components of CAEP were changed according to vowels and emotion reflecting exogenous and endogenous aspects.

Material and methods: Twenty young adults with normal hearing (10: M, 10: F) participated. CAEPs elicited by vowels (/u/, /a/, /i/) out of Ling 6 sounds with angry (A), happy (H), sad (S), and neutral (N) emotions were analyzed by latencies and amplitudes of P1, N1, P2, and N2.

Results: Latency showed statistical differences in P1 by gender, N1 by emotion, P2 by emotion and vowel, and N2 for emotion ($p<.05$). Amplitude showed statistical differences in P1 by gender, P2 by vowel and N2 for all three main effects ($p <.05$).

Conclusions: P1 showed gender difference agreeing with previous studies. Emotional aspects were sensitive to most of elements (latency: N1/P2/N2, amplitude: N2) reflecting endogenous aspect. Vowels showed statistical difference in latency and amplitude of P2.

Continuous noise maskers reduce cochlear implant related artifacts during electrophysiological testing

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Objectives: In the current study, we show that in the presence of a noise masker, the power up onset electrical artifact is greatly reduced compared to the quiet condition. In addition, we compared CI artifacts recorded in the attended and unattended listening.

Material and methods: CAEPs were recorded from 64 scalp electrodes in quiet and noise as well as attended and unattended conditions. Speech stimulus was a synthesized /ba/. For the noise condition, white noise (SNR +5 dB) was presented with the speech stimulus.

Results: The CI artifact was characterized as an onset and sustained response starting at 14 ms after stimulus onset in quiet condition. The noise masker reduced the onset and sustained artifact to an extent where ICA was not visible in the majority of cases.

Conclusions: The current study showed that the noise masking was an effective method for CI artifacts rejection. This may be desirable in clinical situations where the time/software/hardware limitations exist.

Auditory evoked potential (ABR and cognitive potential) in children with a history of otitis media

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Objectives: The aim of this study was to explore differences in auditory evoked potential and auditory processing responses in children with a history of otitis media and bilateral ventilation tube placement, in comparison to a control group.

Material and methods: 90 children aged between eight and 14 years of age in two groups: 40 normal hearing and 50 bilateral myringotomy. Were performed: complete audiological evaluation, auditory processing, Click ABR and auditory cognitive potential.

Results: The results showed significant differences between the control group and the otitis media group in: all auditory processing; Click ABR (waves III and V); auditory cognitive potentials (P2, N2 and P300) – $p<0.05$.

Conclusions: Results showed poorer performance on auditory abilities such as binaural integration, figure-ground, temporal resolution and ordering and significant latency and amplitude changes on auditory evoked potential.

The use of the middle latency response as an indicator of anaesthetic depth: An investigation using a slow induction of propofol anaesthesia

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Objectives: The aim of this study is to test the use of the middle latency response (MLR) in a clinical setting as a monitor of anaesthetic depth, using a support vector machine (SVM) approach to classify the responses at different effect-site concentrations.

Material and methods: Ten patients were included in the study. Auditory stimuli consisted of chirps delivered at 143 Hz using maximum length sequences. We assessed the SNR using the F-value at a single point and tested for MLR significance using a bootstrap procedure.

Results: We observed a significant change in amplitude and latency of the MLR, which is more consistent when progressing to deep anaesthesia. However the large individual variability results in poor classification performances, with an accuracy of 77.9%.

Conclusions: Our findings underline that the relation between anaesthetic concentration and auditory evoked responses is complex and not fully understood and alert on the limitations of the clinical application of MLR as an anaesthetic monitor.

Exploration of inter-individual variability in cortical responses to natural English sentences

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Institute of Sound and Vibration Research, University of Southampton, United Kingdom

Objectives: Grand average cortical responses to speech have shown the possibility to analyse perceived intelligibility. Cortical responses to sentences are explored to determine their variability amongst subjects and therefore their applicability in clinic.

Material and methods: EEG responses to 100 repeats of three English sentences were recorded for 16 subjects with normal hearing thresholds. Responses were detected using a Hotelling's T2 test on 100 ms low-pass filtered (30 Hz) segments (two 50 ms features per segment).

Results: Participants showed a clear response at segments including the stimulus onset ($p<0.01$). Later segments showed strong variability in detection between participants, with less significant responses and more repeats needed compared to onset detection.

Conclusions: Onset responses to natural sentences can be detected within 100 repeats (100 s), which is relevant for clinical use. The possibility of detecting robust responses beyond the onset at an individual level need to be further investigated.

Simultaneous Acquisition of 40 Hz and 80 Hz Auditory Steady-state Responses for a Direct Comparison of Response Amplitude, Residual Noise and Signal-to-noise Ratio

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Objectives: The purpose of this study was to establish a paradigm that allows for the simultaneous recording of auditory steady state responses (ASSRs) for two largely different modulation rates for a direct comparison of response amplitude and residual noise.

Material and methods: In 20 normal-hearing adults ASSRs for 40 Hz and 80 Hz modulation rate were recorded in a monotic single, a monotic simultaneous condition, and a dichotic simultaneous condition.

Results: In all conditions, the 40 Hz ASSR was considerably larger than the 80 Hz ASSR. The residual noise was only 1.4 times larger for 40 Hz than for the 80 Hz.

Conclusions: Simultaneous acquisition of 40 Hz and 80 Hz ASSR provide more reliable information about amplitude reduction caused by interaction between multiple stimuli and residual noise under identical states of vigilance.

Audiometric thresholds estimation using simultaneous acquisition of ASSR and ABR from QASSR in sensorineural hearing loss

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Objectives: The goal was to evaluate the accuracy with which the QASSR method predicts behavioral thresholds in adult patients with sensorineural hearing loss.

Material and methods: QASSRs were analyzed for thresholds and magnitude/phase characteristics. Tone-burst ABR was recovered from QASSR signal and analyzed in the time domain. The QASSR and recovered ABR thresholds were compared to behavioral thresholds.

Results: All mean threshold estimates differed less than 3 dB for QASSR and less than 5 dB for ABR at 1 k, 2 k and 4 kHz. The largest differences were observed for both at 0.5 Hz (5.63 and 11.56 dB).

Conclusions: QASSR method merges two dissimilar stimulation techniques, transient and steady-state, to create a hybrid stimulation-and-analysis paradigm that seems to improve the overall performance of the electrophysiological threshold estimation.

New Objective Way to Diagnose Cochlear Dead Regions using Auditory Steady-State Responses

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Objectives: The aim of the present study was to develop a fast and reliable method for detection of cochlear dead regions (DRs) using Auditory Steady-State Responses (ASSRs).

Material and methods: The ASSRs were measured in normal-hearing participants with MASTER system. Exponentially amplitude modulated (AM2) target tones were presented over a TEN noise that was filtered by a sweeping notch.

Results: Since the sweeping notch makes the TEN less effective as masker when the notch frequencies are close to that of the tone, the ASSR amplitude is largest at the frequency at which the signal is detected, i.e. edge frequency of a dead region.

Conclusions: The ASSR amplitude curves obtained using this protocol might be a quick way to diagnose cochlear DRs in children and adults who cannot provide behavioural responses.

Method for simultaneous air and bone conduction hearing screening

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Objectives: To develop and test a new method for simultaneous air and bone conduction hearing screening using simultaneous air and bone Auditory Steady-State Response (ASSR) and Intensity-Ramping technique.

Material and methods: Click air and bone conduction stimuli were presented simultaneously at different presentation rates. The ramping process allows for the stimulus intensity to vary 40–60 dB. A rate specific envelope detection filter was used to determine responses.

Results: Data from 36 infants were analyzed. Response amplitudes were larger for bone conduction stimulation suggesting the presence of a possible conductive component. Air conduction responses were smaller in infants taking longer to pass screening.

Conclusions: The proposed technique will allow for more accurate characterization of auditory function at the time of screening, more efficient management of hearing loss cases and implementation of more efficient rescreening policies. Funded by NIH NIDCD grant.

Intracochlear Recordings of Acoustically and Electrically Evoked Potentials in Nucleus Hybrid L24 Cochlear Implant Users and Their Relationship to Speech Perception

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Objectives: The goal of this study was to determine the extent to which electrically evoked compound action potential (ECAP) and electrocochleography (ECoG) response were related with speech perception in 25 Nucleus Hybrid L24 cochlear implant (CI) users.

Material and methods: ECAP and ECoG were recorded from an intracochlear electrode. Speech perception was assessed using CNC test and AzBio test (+5 dB SNR): hybrid (A+E) and electric (E) alone modes tested, acoustic (A) gain derived by subtracting these two scores.

Results: ECAP amplitudes were significantly correlated with CNC scores measured in the E alone and A+E modes. ECoG magnitudes to 500 Hz tone bursts were correlated with a composite metric relating the additional benefit of A gain in noise relative to quiet.

Conclusions: Both ECAP and ECoG measures can be recorded from Hybrid L24 CI users and both measures results in more complete characterization of speech perception outcomes than either measure alone.

Distinct elongated EABR wave latencies observed in auditory neuropathy patients with OTOF mutations

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Objectives: Auditory neuropathy with OTOF mutation is caused by a disrupted function of the ribbon synapses accompanying preserved cochlear hair cell activities and normal neural conductions. For evaluating post synaptic functions of this disease, we used EABRs.

Material and methods: We compared the EABRs responses of patients with CI implantations between those who have OTOF (n=6) /GJB2 (n=7) /SLC26A4 (n=4) mutations or CMV infections (n=4).

Results: We observed the distinct elongated EABR wave V latencies in patients with OTOF mutations. Our results indicated that cochlear nerve synchronies were reduced in OTOF patient while primarily neuronal conduction would be preserved.

Conclusions: The disturbed synchronies observed in OTOF patients could to be caused by delay of pre- and post- synaptic neural network maturations. We unveiled a novel pathophysiology of auditory neuropathies caused by OTOF mutations.

Comparison of TT-ECochG and directly recorded cochlear nerve action potentials measured during vestibular Schwannoma resection

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Objectives: To evaluate and compare cochlear nerve action potential (AP) measured from promontory and directly from nerve (DCNAP), and to present their morphology pattern changes recorded during subsequent stages of vestibular Schwannoma (VS).

Material and methods: Ten patients with VS and preserved hearing were included to this study. VS were removed via middle fossa approach. Recording electrodes were placed on the promontory and nearly directly on the cochlear nerve. Ears were stimulated by 80 dB nHL click.

Results: All potentials, AP and DCNAP, were compared. Patterns of morphology changes were different for both potentials, DCNAP latency delay were longer in comparison to AP from promontory and amplitude reductions differed confirming retrochochlear damages.

Conclusions: Intraoperatively recored AP and DCNAP provides information about activity and probable damages of hearing pathway from its different levels. It makes intraoperative monitoring of hearing more comfortable and easier for retrocochlear pathologies.

Intraoperative Ossiculoplasty Efficiency Assessment by RW-ECochG

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Objectives: To assess intraoperative air-bone gap closure (I-ABG-Closure) during ossiculoplasty using round window electrocochleography (RW-ECochG).

Material and methods: Forty patients with cholesteatoma undergoing second stage ossicular reconstruction surgery were included to this study. Ossiculoplasty efficacy was evaluated by intraoperatively measured RW-ECochG thresholds defined as a presence of CAP-N1 peak.

Results: Six months postoperative ABG-Closure ranged between 10 to 45 dB and correlated with I-ABG-Closure ($r>0.5$; $p<0.05$). Prosthesis configuration and placement resulted in measurable changes in I-ABG-Closure evaluated as a RW-ECochG thresholds.

Conclusions: RW-ECochG was a very effective tool for evaluation of I-ABG-Closure showing good correlation with postoperative hearing status in cases of second stage ossiculoplasty.

Poorer hearing in noise despite full recovery of thresholds in rats: Functional evidence of "hidden hearing loss"?

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Objectives: Noise exposures that produce robust temporary threshold shift (TTS) reduce auditory brainstem response (ABR) wave-I amplitude. This study evaluated whether these ABR reductions were associated with functional hearing-in-noise deficits.

Material and methods: ABR threshold and amplitude, otoacoustic emissions, and hearing-in-noise were assessed in rats before and after noise exposure (106 or 109 dB SPL octave band noise, 8–16 kHz, 2 h). Hearing-in-noise was assessed at various signal-to-noise ratios (SNR).

Results: The 106 dB SPL exposure had no effect on ABR or hearing-in-noise after 2 weeks. In contrast, the 109-dB SPL noise reduced ABR wave-I amplitude at 16–24 kHz and showed hearing-in-noise deficits in the poorest SNR condition, despite threshold recovery.

Conclusions: Reduced wave-I amplitude and poorer hearing-in-noise were observed after noise exposure producing robust (>30 dB) TTS at 24 hrs post exposure. Future studies should assess effects of lower level, repeated, exposures that model occupational noise.

Clinical Measurements for Investigating Hidden Hearing Loss

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Objectives: The aim of the present study was to compare clinical measurements of auditory function in two different listener groups prone to hidden hearing loss (tinnitus, noise-exposed) to a control group.

Material and methods: ABR wave I, III and V were measured to quantify the level-growth of wave I and the difference in amplitude between wave I–III and I–V. For the control and noise-exposed groups, high-frequency sensitivity and speech in noise was also measured.

Results: No difference between the control and tinnitus group in the growth of wave I, nor hyperactivity in the midbrain was found. The noise-exposed group did not show correlation between high-frequency sensitivity and speech-in-noise performance.

Conclusions: None of the applied audiological methods indicate signs of hidden hearing loss in the two groups of listeners considered. The results suggest that a refinement of audiological methods might be required to investigate hidden hearing loss.

Lifetime noise exposure affects human auditory brainstem responses

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Objectives: Whether noise-induced cochlear synaptopathy occurs in humans has not yet been definitively demonstrated. We aimed to evaluate the effects of lifetime noise exposure (LNE) on auditory brainstem responses (ABRs) recorded at supra-threshold level.

Material and methods: ABR waves I and V amplitudes were measured at 108 dB ppeSPL rarefaction clicks in 68 normal hearing subjects. A linear regression model was fitted with age, gender, lifetime noise exposure, and audiometric pure-tone thresholds as predictor variables.

Results: Despite large inter-subject variability in noise exposure and ABR amplitudes, we found a statistically significant effect of LNE on the amplitudes of waves I [–0.06 μV/log10(Pa2/h), p-value 0.009] and V [–0.09 μV/log10(Pa2/h), p-value 0.001].

Conclusions: The statistically significant trends observed in our results are consistent with the presence of noise-induced cochlear synaptopathy in humans. They also suggest that this pathology is present in most adults, except for those with very minimal LNE.

Comparison of high-frequency distortion product otoacoustic emissions measured by two systems

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Objectives: Distortion product otoacoustic emissions (DPOAE) are most commonly measured up to 6 kHz. However, there are now systems available that can measure DPOAEs up to 16 kHz. The purpose of this study was to compare two such systems.

Material and methods: DPOAEs were measured by the HearID+DP (Mimosa Acoustics) and SmartDPOAE (Intelligent Hearing Systems) at frequencies from 0.5 to

16 kHz. Short-time repeatability was assessed by comparing DPOAE amplitudes between two measurements.

Results: DPOAEs were above the noise for all tested frequencies. The differences between consecutive measurements and between the two systems was lowest in the 1–8 kHz range and highest in the 9–16 kHz range.

Conclusions: Both systems provided DPOAE levels that were consistent with normal hearing thresholds. However, the differences between the two systems were quite high and may be too large to detect small changes in cochlear status if different equipment is used.

Pressurized vs non pressurized Otoacoustic Emissions: A case report

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Objectives: The present study aimed to compare the OAE response obtained with and without an ear pressure equalization at 0 daPa.

Material and methods: Two young male adolescents, aged 12 (subject 1) and 11.5 (subject 2) years old with normal hearing. Were performed Wideband Tympanometry, Transient otoacoustic emissions in pressurized (0 daPa) and non-pressurized conditions.

Results: Subject 1: TEOAE were Pass for both conditions. Subject 2: FAIL in the ambient pressure condition and as Pass in the pressurized condition (the highest difference was observed at 3 kHz and 4 kHz were the difference values were approximately 5 dB).

Conclusions: The data suggest the possibility, that a pressurized TEOAE condition might be a promising tool for evaluating properly the cochlear function, by passing the influence of middle ear complications.

The effect of bone-conducted stimuli at different stimulation sites on contra- and ipsilateral ocular vestibular evoked myogenic potentials

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Objectives: Ocular vestibular evoked myogenic potentials (o-VEMPs) are performed to assess utricle function of the human vestibular system. oVEMPs are obtained using high-level bone conductor (BC) stimulation as opposed to conventional B71 BC or just AC stimuli.

Material and methods: This study investigated stimulation site (M1/M2 vs Fz/Cz) using high-level Bandamp;K 4810 transducer. 1- and 2-channel setups were compared and the necessity to obtain simultaneously contra- and ipsilateral recordings using a 'belly-tendon' montage.

Results: Based on amplitude, latency, interocular ratio and stimulation threshold, in contrast to stimulation at Cz/Fz, mastoidal stimulation show higher ipsilateral responses, with lower interocular ratios with Fz/Cz stimulation.

Conclusions: The surplus value and (un)necessity of interpreting contra- and ipsilateral responses to BC stimulation for different stimulation sites is addressed, resulting in more optimized protocol for high-level BC stimulation.

Evaluation of air-conducted cervical and ocular vestibular evoked miogenic potentials in patients with Susac's syndrome

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Objectives: To evaluate acoustically evoked cervical and ocular vestibular miogenic potentials (AC cVEMP and oVEMP) findings in patients diagnosed with Susac's syndrome (SS).

Material and methods: Two patients with SS were tested. The stimuli (500 Hz frequency tone bursts) were presented unilaterally one ear at a time. The resulting VEMP waveforms were analyzed for the response presence, latency and amplitude in the time domain.

Results: Patient#1, responses on both sides showed latencies within normal limits for both c- and oVEMP; small amplitudes for cVEMP. Patient#2, only cVEMPs were present; latencies within normative values, amplitudes low and asymmetric between sides.

Conclusions: The combined application of AC cVEMP and oVEMP may provide additional and useful information about affected vestibular system and be of help in treatment and rehabilitation planning in patients with Susac's syndrome.

Splenius capitis can be a replaceable target for measuring cervical vestibular evoked myogenic potentials

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Objectives: The cervical vestibular evoked myogenic potentials (cVEMPs) require tonic sternocleidomastoid (SCM) recruitment, often achieved through an uncomfortable head position. Here, we aimed to analyze the splenius capitis (SC) as a new target for cVEMPs.

Material and methods: cVEMPs were recorded from both SCM and SC in 5 healthy male subjects (43.6±4.7 years) with two head positions (45° and 90° turned). For all subjects, computed tomography of neck was performed and the volumes of SCM and SC were calculated.

Results: Clear cVEMPs were observed at 45° and 90° for SC, while only 90° for SCM. P1-N1 interamplitudes were smaller in SC (119.5±138.6) than SCM (246.8±179.1 uV). There was no significant difference between SCM (39.8±4.9) and SC volumes (38.5±9.9 mm^3).

Conclusions: Adequate tonic SCM contraction could not be achievable in some clinical situations. This study showed that SC with simple head-turned postures can be a new target of cVEMPs with moderate levels of muscle activation even in children and the elderly.

Cortical auditory evoked potential (CAEP) in patients with cochlear implantation

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Objectives: The aim of this study was to evaluate the characteristics of cortical auditory evoked potentials (CAEP) to different types of sound stimulation in CI listeners using a commercially available system, HEARLab™.

Material and methods: Sound field CAEPs were obtained from 10 adults and 23 children of CI, using three natural speech sounds (/m/, /g/, /t/) at 55, 65, and 75 dB SPL. Detection rates, latencies and amplitudes of waves were analyzed and compared.

Results: /g/ showed the most robust waveform. Latencies were longer in /m/ than in /t/ and /g/, suggesting high-frequency sound preference in CI listener. CAEP of CI listeners showed smaller amplitudes and longer latencies (especially of P1) than NH group.

Conclusions: CAEP responses could be obtained in all CI listeners, indicating that CAEP can be applied clinically as an objective assessment tool of hearing. Further studies are needed in infants and toddlers using this protocol to assess its clinical usefulness.

Poster Session II

Wednesday, May 24th

Advancing toward an objective EEG detection method for supra-threshold deficits

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Objectives: Our main goal is to develop objective EEG measures of supra-threshold deficits. We aim to develop new FFR measures of 1) the precision of temporal processing and 2) of functional auditory deafferentation.

Material and methods: For temporal processing, we measure how adding temporal jitter to stimuli deteriorates the FFR. For deafferentation, we measure FFRs deterioration when recorded iteratively (FFR to one stimulus is used as a stimulus for another FFR recording).

Results: Jittering should affect less people with worse temporal precision. Perceptually, a functional deafferentation can be thought of as a 'noisification' process; hence deafferentation should lead to a faster deterioration of the FFR through iterations.

Conclusions: Developing objective and sensitive EEG measures can help diagnose supra-threshold deficits that do not always manifest in elevated audiometric thresholds, as well as help personalize hearing deficits remediation.

Is a chirp a prihc?

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Objectives: To compare ABR responses to forward and reversed band limited chirps (chirps and prihcs). If a band limited chirp improves neural synchrony then time reversing it should reduce synchrony. To explore time-frequency properties of band limited chirps.

Material and methods: Band limited chirps were sampled from a commercial EP system. ABRs recorded from 15 normal hearing adults to 3 stimuli: NB Chirp, Time-reversed NB Chirp, Tone pip. At 30 and 50 dB HL, 0.5 and 4 kHz. Time-frequency analysis of signals was conducted.

Results: Responses to chirps and prihcs were similar. However data quality at low frequency/level was limited. The smallest resolvable frequency increases with duration as $\Delta t \Delta f = 1$, so for short chirps, the smallest resolvable frequency difference is high.

Conclusions: Time-frequency sweeps intended using band limited chirps may not be resolvable by the cochlea. Chirps give similar responses to prichs. Our findings raise questions over whether short duration band limited chirps should be described as chirps.

Effects of the Noise Reduction of Hearing Aids on cABR

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Objectives: The purpose of this study was to identify difference in the brainstem processing of speech and speech with noise using noise reduction algorithm of hearing aids.

Material and methods: Thirty adult participants were recruited from the Korean native speaker: The stimulus was a 170 ms [da] syllable and presented 70 dB SPL and 0 dB signal-to-noise ratio (SNR) with white noise using loudspeaker.

Results: As a result, hearing loss groups showed different response between the characteristics of hearing loss in performance of noise reduction algorithms.

Conclusions: The results indicate that the effect of noise reduction algorithm must need to consider personal characteristic of hearing loss.

Temporal masking at the brainstem level: A pilot study

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Objectives: This study investigates ABR responses to temporally masked sounds with varying intervals between tone and noise. This would show the effect of different intervals in backward (BM) and forward (FM) masking on brainstem representation of sounds.

Material and methods: A 2 ms tone (4 kHz) plus a 40 ms noise (3.6–4.4 kHz) were presented (SNR: –5 dBSL) with 4 different intervals (18, 9, 3, 0 ms) at 8.9/s rate to 7 adults, in 3 masking conditions (BM, FM and simultaneous[SM]). ABR response was also obtained for tone only.

Results: From quiet to SM, decreasing intervals between stimuli led to significant and gradual latency increase and amplitude decrease in both BM and FM. Latency did not differ between BM and FM, but FM showed a trend to smaller amplitudes.

Conclusions: ABR measures demonstrated effects of temporal masking for both BM and FM, and shorter intervals between signal and masker also affect the response. Albeit preliminary, the results surely point towards a trend. More data should be obtained.

Speech-evoked brainstem response in children and adolescent with education musical

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Objectives: The aim of the study was to assess the auditory processing for speech stimuli, in children and adolescents having already a musical education.

Material and methods: Fifty children and young adolescents (28 female and 22 male; age: 8–14 y) with music background. All subjects were Italian native speakers. Speech ABR were elicited by the synthesized syllable /da/ at 80 SPL using the Biologic Navigator Pro equipment.

Results: Results showed better values of latencies with significant statistically differences in the right ear (waves E and F) and the left ear (waves D e O). Amplitude values was observed higher amplitude only for the wave F values in the left ear.

Conclusions: The results of the present study demonstrate that children and adolescents with music education show better responses in the assessment of speech ABR.

Gene therapy by in-utero rescues hearing function in a mouse model of genetic hearing loss

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Objectives: Hearing loss is a highly prevalent sensory defect in humans. Nevertheless, there is no fundamental therapy to treat this disease. Gene therapy is a promising approach to restore hearing.

Material and methods: We achieved gene delivery by introducing a recombinant adeno-associated virus (rAAV) expressing the MsrB3 gene directly into the otocyst. we analysed the functional and histological changes of ears of MsrB3−/− and MsrB3+/+ mice.

Results: We observed hearing recovery in the treated ear of the MsrB3−/− mice. We confirmed mRNA and protein expression in the ear, and rAAV-rescued ears exhibited normally shaped hair cells, similar to those of control MsrB3+/+ mice.

Conclusions: To our knowledge, this is the first study to demonstrate restoration of hearing in a mouse model of hearing loss using an in utero, virus-mediated gene therapy. Our results provide a significant advancement in the treatment of hearing loss.

The clinical utility of narrow-band chirp auditory brainstem responses: Inter-rater reliability and threshold estimation

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Objectives: Tone-burst auditory brainstem responses (TB ABR) are traditionally used in infants. However, more recent studies show that narrow-band (NB) chirps have several advantages over TB ABR. This study compares reliability of NB-chirp and TB ABR.

Material and methods: ABRs were obtained with TBs andNB-chirps (0.5, 1, 2, 4 kHz). Inter-rater reliability of NB-chirp and TB-ABR are assessed, signal-to-noise ratios, and finally, thresholds obtained by pure-tone audiometry, TB ABR, and NB-chirp ABR.

Results: Good inter-rater reliability was found (all f's) at maximum and threshold level. Preliminary analysis suggests that NB chirps elicits better responses than TBs except for 0.5 kHz, which is more difficult to interpret (both stimuli types).

Conclusions: NB chirps can be obtained with good inter-rater reliability. Further statistical analyses and comparisons between behavioral, TB ABR, and NB-chirp ABR thresholds will be presented and discussed.

Subcortical plasticity in tinnitus subjects following exposure to short and intense notched music training

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Objectives: TMNMT is a novel treatment tinnitus approach that aims to reverse maladaptive cortical plasticity. It has been hypothesized that the short-term application of TMNMT can also reverse maladaptive subcortical plasticity resulting from tinnitus.

Material and methods: cABRs were recorded in nine normal-hearing individuals with tinnitus. The TMNMT was accomplished compressively during 5 contiguous days. The effects of TMNMT on the cABR component and tinnitus loudness were investigated.

Results: The latency of cABRs in wave V was shorter after music training than before. There was a significant difference in visual analog scale and loudness matching measurements and no difference in THI scores before versus after TMNMT.

Conclusions: This finding indicated prompt neural reorganization of the brainstem in tinnitus patients with exposure to TMNMT. It seems that TMNMT may partially reverse maladaptive plasticity at the subcortical level; however, the recovery was partial.

Cortical auditory evoked potentials in noise under conditions of masking release

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Objectives: The goal of the present study was to investigate the applicability of CAEP in response to complex stimuli under conditions of across-frequency and binaural masking release.

Material and methods: CAEPs were measured using a 64-ch EEG system with active electrodes (Biosemi ActiveTwo). To vary the detectability of the masked tonal stimulus, auditory cues known to evoke a masking release were introduced.

Results: The results show that the amplitude of CAEP increase as a function of stimulus level. Only the P2 component of the CAEP correlated with the behaviorally found level above masked threshold.

Conclusions: The CAEP data suggest that only the P2 amplitude is a indicator of the audibility of signals including cues for masking release. The interpretation of the P2-N1 amplitude might easily be confounded by the presence of auditory unmaksing cues.

Mismatch response versus acoustic change complex: Assessment of auditory temporal fine structure processing – finding an objective paradigm

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Objectives: This study aims to define an objective electrophysiological paradigm to assess temporal fine structure (TFS) processing. Acoustic change complex (ACC) and mismatch responses (MMR) are compared to each other and to behavioural thresholds (BT).

Material and methods: 14 normal hearing participants were recruited. BTs were acquired with the TFS1 test consisting of complex harmonic tones and their frequency shifted versions. Neural responses were obtained for the ACC and MMR paradigm for differing frequency shifts.

Results: The two neurophysiological paradigms are compared with regard to efficiency and signal-to-noise ratio to determine the more robust and time-efficient paradigm. Preliminary results show decreasing neural responses with decreasing frequency shift.

Conclusions: Objective measures of TFS processing may provide information of clinical relevance to improve the assessment of hearing abilities with potential future applications in cochlear implant users.

Comparison of auditory p300 in amphetamine users and non-users of other narcotics, psychotropics and other addictive substances

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Objectives: To measure latency period, amplitude of auditory P300 in amphetamine user and non-user of other narcotics, psychotropics and other addictive substances involving cognitive function.

Material and methods: Descriptive research with cross-sectional comparative study was used. Adult (18–40 years old) subjects, amphetamine, other narcotics, psychotropics and other addictive substances users and non-users were collected consecutively.

Results: Fifteen subjects showed impaired cognitive function andwas significantly correlated shown by Fisher's test.

Median for latent period is longer in amphetamine users compared to non-users. Median amplitude in both groups are statistically insignificant.

Conclusions: The median, both during the latency period and amplitude, for the two groups was still within the normal range. Nevertheless, there was a tendency for latency period to prolong amongst amphetamine users.

Preliminary results on the P300 auditory event-related potential as a method to assess the benefit of wearing a contralateral hearing aid in bimodal listeners

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Objectives: The unexplained variability in bimodal outcome impedes clinicians to provide evidence-based counseling regarding contralateral hearing aid use. This study explores whether bimodal benefit can be assessed using P300 event-related potential (ERP).

Material and methods: Cognitive P300 ERPs were recorded in bimodal listeners using a low-frequency tonal contrast. The accuracy of the count served as a measure of behavioral performance. To assess binaural benefit, CI-only and bimodal listening were compared.

Results: P300 were reproducible in most subjects. Latencies decreased and amplitudes increased in bimodal versus CI-only listening. Subject with largest ERP improvement showed largest improvement in behavioral performance.

Conclusions: Preliminary data suggest that the P300 ERP may be a valuable technique to objectify the benefit from wearing a contralateral HA.

Effect of polarity of 500 Hz tone pip on wave V threshold

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Objectives: Evaluation of low-frequency audiometric threshold based on ABRs evoked with frequency-specific stimuli creates problems. The aim is a to find acquisition and stimulation ABR parameters that allow for better correlation between wave V threshold and audiometric threshold.

Material and methods: ABRs were registered in physiologic sleep in a group of 10 normal-hearing persons. The stimuli were 500 Hz tone-pips of positive, negative and alternating polarity. One applied the intensity series procedure to determine wave V threshold.

Results: Average values of wave V threshold for different stimulus polarities significantly differ from one another. The lowest ABR thresholds one obtained with negative stimulus polarity, while alternating polarity yields the highest threshold value.

Conclusions: One recommends that tone-pips with negative polarity should be used when one evaluates hearing threshold at the frequency of 500 Hz.

Objective evaluation of visual and cognitive functions in children with central auditory processing disorders (CAPD) – an event-related potentials (ERPs) study using the Visual Continuous Performance Test

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Objectives: Objective behavioral tests suggest that central auditory processing disorders (CAPD) are not only a dysfunction of higher auditory mechanisms but can also be related to malfunctioning of general cognitive processes. The aim of the study was objective assessment of cognitive functioning of children with central auditory processing disorders (CAPD) based on changes in the event-related potentials (ERPs) recorded in the Visual Continuous Performance Test (VCPT).

Material and methods: The study involved 13 CAPD and 16 healthy children. Auditory processing was assessed on the basis of 5 behavioral central auditory tests (CAT), while cognitive processing by measuring amplitude and latency of ERPs acquired in the VCPT test.

Results: CAPD children had lower scores than healthy children in 3 from 5 CAT. They also revealed increased amplitudes of N1 and P2 waves in passive, Go and NoGo trials, and longer N2, P3 latencies and a lower P3 amplitude in NoGo trials of the VCPT test.

Conclusions: The results indicate more effective visual processing and cognitive (inhibitory control) deficits in children with CAPD. The cognitive functions impairment could be important in CAPD etiology.

Comparing cortical evoked auditory potientials using HEARLab with stimulus sensation levels in children with hearing aids.

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Objectives: The aim of this study was to investigate the significance of obligatory cortical auditory evoked potentials (HEARLab™) in children with sensorineural hearing loss based on their estimated stimulus audibility thresholds.

Material and methods: Sound field CAEP recordings to speech-based stimuli (/g/, /t/ and /s/) (HEARLab) from hearing-impaired children, aided or unaided. Audibility values (dB SL) based on hearing thresholds, RECD and REAG values for each individual, and stimulus levels.

Results: CAEP responses were in accordance with audibility values in a majority of test sessions. However, in some test sessions CAEP responses did not reach significance despite good audibility values.

Conclusions: CAEP as an objective measure for evaluating hearing in children is a promising tool, but should be evaluated with care. Several factors may affect our results; hearing aid processing of test stimuli, estimation of audibility and child cooperation.

Characteristics of auditory brainstem evoked potentials in subjects with Down syndrome

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Objectives: Auditory brainstem evoked potentials (ABR) may be useful for objective hearing testing in persons with Down syndrome. The aim of the study was to find whether normative values of ABRs determined in normal-hearing persons are valid for patients with Down syndrome.

Material and methods: The tests were carried out in two, balanced group of subjects, normal hearing persons and patients with Down syndrome. Intensity series of ABRs were recorded using click stimulus. Wave V latency, inter-pick intervals and intensity-latency functions were determined.

Results: Average value of I–III interval was significantly shorter in Down-syndrome patients than in normal-hearing subjects, while III–V intervals didn't differ statistically. Latency-intensity function was steep in Down-syndrome patients.

Conclusions: In objective diagnostics of hearing impairments in Down syndrome patients with the use of ABRs one should use normative values of wave characteristics specific for that group of persons.

Correlation between the behavioral hearing thresholds (BHT) and electrophysiological (auditory steady-state responses – ASSR) in young adults

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Objectives: To analyze the correlation between behavioral hearing thresholds (BHT) and electrophysiological thresholds (ASSR) at frequencies of 0.5, 1, 2 and 4 kHz in young adults.

Material and methods: 15 males and 15 females with normal hearing (18–40 y). BHT and ASSR (with predefined modulation frequency): 0.5, 1 k, 2 k and 4 kHz. Statistical analysis used the Pearson Linear Coefficient (r).

Results: Mean of differences between auditory thresholds obtained in BHT and ASSR were: 0.5 Hz: 18.22 dB, 1 kHz: 15.18 dB, 2 kHz: 11.08 dB, 4 kHz: 10.47 dB. Correlation coefficient (r): 0.5 Hz (r=0.44), 1 kHz (r=0.20), 2 kHz (r=0.29) and 4 kHz (r=0.35).

Conclusions: Observed: mean correlation at 0.5 Hz, weak correlation at 1 kHz, 2 kHz and 4 kHz. For individuals with normal hearing it was possible to verify a low correlation between BHT and ASSR.

It's all about context: Investigating the effects of consonant and vowel environment on vowel-evoked envelope following responses

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Objectives: The envelope following response (EFR) has proven useful for studying brainstem speech processing, but its amplitude varies across stimuli. This study aims to determine if this variation is attributable to consonant or vowel context of the stimulus.

Material and methods: Single-channel EFRs were recorded from 31 normal hearing adults. Stimuli were 7 vowels (ij,ɪ,ej,ɛ,æ,u,ɔ) each embedded in 4 consonant contexts (h-d,s-t,z-f,ʒ-v) spliced from naturally spoken English tokens and edited to remove coarticulation.

Results: EFR amplitudes were significantly affected by vowel identity. On average, /æ/ elicited the highest amplitudes, and /ej/ the lowest. Consonant environment was also significant; preliminary analysis suggests /ʒ-v/ elicited the highest amplitudes.

Conclusions: This study is important for developing more effective stimuli for eliciting EFRs for research and clinical purposes. Results indicate strong effects of vowel and consonant context on EFR amplitude, and will be updated from ongoing data collection.

Frequency-specific phase shift varies detectability of vowel-evoked envelope following responses

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Objectives: Phase interactions between responses from multiple cochlear regions may affect the amplitude of envelope following responses (EFRs) elicited by some vowels. We tested this hypothesis by measuring EFRs to vowels with varied relative formant phase.

Material and methods: EFRs to 8 variants of naturally produced vowels /e/ and /u/ were recorded in 36 young normal hearing adults. The second and higher formants (F2+) of each vowel was shifted relative to the first formant (F1) by 0 (no shift) to 315 deg in 45 deg steps.

Results: In most participants, EFRs to /e/ reached maximum amplitude between shifts of 90 and 225 deg. In contrast, phase shifts did not elicit consistent trends in response to /u/. Larger changes in EFR amplitude occurred with stronger F1 band contributions.

Conclusions: Scalp-recorded EFRs evoked by vowels are composite responses from temporally dispersed neural activity due to cochlear delay. Introducing a phase delay between formant bands could improve EFR amplitude, and thus, detectability in some vowels.

Stimulus bandwidth impact to AEP thresholds and estimated upper-frequency limits of hearing in toothed whales

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Objectives: The frequency bandwidth of toothed whale hearing can exceed 120 kHz. No consensus on stimuli for testing toothed whales exists, yet stimulus bandwidth potentially affects determination of the frequency limits of hearing.

Material and methods: AEP threshold variability due to stimulus bandwidth of tone-pips and AM tones was determined in dolphins near their upper-frequency limit (UFL) of hearing and ½ to 1-octave below. Subjects included normal and hearing-impaired dolphins.

Results: Thresholds at frequencies where hearing is sensitive showed minor changes with changing stimulus bandwidth. Thresholds near the UFL of hearing declined with increasing stimulus bandwidth, potentially broadening hearing bandwidth estimates.

Conclusions: Thresholds where hearing is sensitive are robust to stimulus bandwidth changes. Near the UFL where sensitivity rapidly declines, stimulus bandwidth affects thresholds through spectral splatter into lower frequency bands of greater sensitivity.

Preliminary results and challenges of artefact reduction in analysis of mismatch responses elicited by amplitude modulation detection in cochlear implant users

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Objectives: This study examines the mismatch response (MMR) as an objective measure of amplitude modulation (AM) detection in cochlear implant (CI) users. Furthermore, the challenges of artefact reduction in electroencephalography (EEG) data are addressed.

Material and methods: 8 Hz AM detection thresholds are measured with an adaptive procedure. 128-channel EEG data is obtained with an oddball paradigm for different AM depths. The common oddball paradigm is compared to a novel approach with regard to CI artefact reduction.

Results: Preliminary results show MMR responses from 2/3 CI users. However, MMR latencies differ greatly and butterfly plots show remaining artefact traces in some channels. Participant numbers will be increased to draw statistically valid conclusions.

Conclusions: CI artefact reduction for discrete stimuli with fluctuating envelopes is challenging. This study presents the opportunity to discuss artefact reduction approaches in relation to the presented data.

Low-Frequency Electrocochleography in a Guinea Pig Model of Cochlear Implantation with Residual Hearing

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Objectives: Interpreting electrocochleography (ECochG) with respect to "cochlear health" in CI patients

with residual hearing has proven to be difficult. We propose an experimental setup to investigate ECochG components in a model of cochlear implantation.

Material and methods: Guinea pig model implanted with custom-built electrode. Intra- and extracochlear ECochG integrated into setup featuring telemetric recording via CI. Stimuli were 100-µs click and 10-ms sinusoidal tone bursts (250 Hz to 64 kHz, 1 step per octave).

Results: Intra- and extracochlear recordings similar and telemetry validated. Transient and ongoing ECochG potentials showed distinct sensitivities to implantation trauma. Spectral analysis of ongoing potentials demonstrate further differences in selectivity.

Conclusions: Our experimental setup validated telemetric low-frequency ECochG in implanted guinea pig model. Spectral analysis of different harmonic components constitute a potentially feasible measure of "cochlear health" in the apex.

Analysis of intraoperative changes of the cochlear nerve action potential during vestibular schwannoma resection

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Objectives: To assess an effect of surgical manipulation during vestibular schwannoma (VS) removal on action potential (AP) morphology changes of the cochlear nerve (CN).

Material and methods: Thirty patients with VS and a good hearing were included to this study. AP was extracted from intraoperatively measured TT-ECochG. All ears were stimulated by 80–85 dB nHL click and analyzed in rarefaction, condensation and alteration option.

Results: In all ears AP amplitude was reduced while latency delayed for all stimulation polarities. These changes were significantly different for both polarities revealing various level of intraoperative hearing damage that correlated with postop hearing.

Conclusions: Intraoperatively measured AP provides information about hearing status and lets predict postop hearing loss. AP morphology changes observed for various polarities gives possibilities to assess some auditory processes occurring intraoperatively.

Analysis of Audio-vestibular Assessment in Acute Low-tone Hearing Loss

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Objectives: To analyze acute low-tone hearing loss (ALHL) without vertigo, we compared the ALHL group with all patients exhibiting low-tone hearing loss and ear fullness. Hearing changes and vestibular functions were analyzed.

Material and methods: ALHL was defined as a mean hearing loss of ≥30 dB at 125–250–500 Hz, and ≤20 dB at 2–4–8 kHz. From 156 ALHL more than 10 dB without vertigo, 31 met the ALHL criteria and subjected to PTA, ECoG, VEMP, and caloric testing.

Results: ALHL was 42.7±9.5 dB, and 83.9% of ALHL significantly recovered by more than 10 dB. The ECoG in ALHL was 0.334±0.11 (higher than 0.25±0.08 on normal side) and ECoG abnormality was 35.5% (the greater low-tone hearing loss, the higher ECoG value).

Conclusions: Excellent hearing recovery following both diuretic and oral steroid, and electrocochleography (ECoG) was significantly higher than normal side. The greater low-tone hearing loss, the higher ECoG, and excellent recovery even-though ALHL is worse.

Correlation of hearing impairment with the conditions of the tympanic membrane perforation and mastoid air cell volume

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Objectives: Correlation of hearing impairment with the conditions of the tympanic membrane perforation and mastoid air cell.

Material and methods: We reviewed records from 128 patients who had undergone myringoplasty. First we evaluated the pure tone audiometrics to analyze the preoperative hearing level. Second, we measured middle ear and mastoid volume via preoperative temporal bone CT scan.

Results: We found negative correlation according to the wideness of mastoid pnumatization. (p=0.003) Whereas, there was no statistically significant result when we compared middle ear volume and preoperative hearing (p=0.48).

Conclusions: Using high-resolution CT, we confirmed that the volume of mastoid air cells is associated with conductive hearing loss, whrereas the volume of tympanic cavity would have no significant effect on hearing loss.

Changes of hearing function in preterm born children with age

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Objectives: In preterm born children sensorineural hearing loss (SNHL) and auditory neuropathy (ANSD) can be both permanent and transient. Hearing improvement associated with maturation or delayed development of auditory dysfunction can be observed with age.

Material and methods: 177 children born before the 33 week of gestational age were examined. The duration of the follow-up was up to 14 years. Tests included: ABR, ASSR, OAE, impedancemetry, pure tone and speech audiometry. Children with conductive HL were excluded.

Results: Initially 21 children had SNHL; 38 – ANSD; 4 – SNHL on one side and ANSD on another one. Repeated studies revealed hearing changes in 9 children. Hearing improvement, transformation of the initial HL, delayed onset of SNHL were observed.

Conclusions: Possible causes of delayed onset of auditory disorders may be the progredient nature of the hypoxic-ischemic lesions of the central nervous system. The observation period for the auditory function in preterm born children must be at least 3–4 years.

Verification of finite element model for the human ossicular vibration performance using 3D printed biomimetic ceramic ossicle

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Objectives: A novel method for developing and analyzing the biomimetic ceramic ossicles (BCO) in combination with 3D printing technology enables to verify the results with established FE model of the human ossicles for analyzing vibration performance.

Material and methods: FE method (FEM) was used for the modal analysis of the human ossicles and biomimetic ceramic ossicles (BCO) made of hydroxyapatite (HA) were fabricated using 3D printing technology, and their vibration properties were measured.

Results: The resonance frequencies of the FEM modal analysis were 669.97, 1205.6, 1452.1, and 3394.1 Hz. Displacement values of the second, third, and fourth natural frequencies differed among the malleus, stapes, incus, MIJ, and ISJ.

Conclusions: FEM and the experimental ceramic model can be used to understand the mechanism of sound transmission through the ossicular chain and to determine the structural and placement parameters.

Electrical stimulation to a vestibule can induce auditory sensation without vestibular symptom in a child with cochlear aplasia

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Objectives: Vestibular implantation (VI) restores vestibulo-ocular reflex (VOR) for patients with bilateral vestibular loss. This study aims to assess the outcome of cochlear implantation (CI) done by the way of inserting the electrode inside the vestibule.

Material and methods: A deaf child who has normally formed vestibule and semicircular canals without cochlea received CI by the way of inserting the electrode inside the vestibule. The outcome of EABR, vestibular function test, and speech perception was examined.

Results: Direct electrical stimulation to the vestibule induced clear auditory sensation without vestibular symptom and nystagmus. EABR tests showed clear waveforms.

Conclusions: This case implies that direct electrical stimulation to a vestibule may evoke auditory sensation, not VOR in a patient with congenital vestibular loss. Application of VI for patients with congenital bilateral vestibular loss needs to be cautious.

Wideband absorbance measures for assessment of otosclerotic ears: A preliminary study

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Objectives: Wide Band Tympanometry (WBT) is a reliable methods for assessment of middle-ear disorders. Literature reports indicate usefulness of WBT for qualification to reconstructive surgery and assessment of surgery results, especially in otosclerosis.

Material and methods: Energy absorbance (EA) measurement was performed, along with other diagnostic tests, in a group of about 20 patients diagnosed for otosclerosis. In some of them the tests were repeated in postoperative period and the effects surgery were assessed.

Results: EA value shows significant changes in otoslerotic ears compared to normal-hearing ones. A meaningful decrease in EA value was observed especially in mid-frequency region, 500–1500 Hz. In many cases, 226 Hz tympanograms in otoseritic ears were normal.

Conclusions: WBT is an effective method for detecting middle-ear disorders, like ossicular chain fixation, disarticulation, etc. It proves much more sensitive than standard low-frequency tympanometry. It may also be used for assessment of surgery results.

Assessment of wideband absorbance in patients with middle-ear implants: A preliminary study

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Objectives: Wide Band Tympanometry is a reliable methods for assessment of middle-ear mechanoacoustic properties. The presence of middle-ear implant, e.g. FMT, alters ear impedance and absorbance characteristics. This problem has not been investigated yet.

Material and methods: Energy absorbance (EA) was measured, along with other characteristics, in the ears of about 20 patients qualified for middle-ear implants. The tests were repeated in postoperative period and the changes in EA properties were assessed.

Results: The presence of FMT changes middle-ear impedance and influences energy absorbance in a specific frequency range. Low-frequency and high-frequency EA remains virtually unchanged. An influence of FMT fixation method on EA is also observed.

Conclusions: Middle-ear implant, of FMT type, influences acoustic impedance and absorbance characteristic due to the increase of mass of the vibrating ossicular system. The observed effects conform qualitatively well to those predicted with the middle-ear model.

Comparison of ABR waveforms between ears in unilateral tinnitus patients

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Objectives: ABR is relatively common diagnostic procedure performed in otologic clinics. In this study, we compared waveform characteristics of the tinnitus ear and non-tinnitus ear in unilateral tinnitus patients with normal hearing.

Material and methods: We compared, amplitude and latency of wave I, III, V and amplitude ratio of III/I, V/I between ears. Amplitude was measured with two different methods which is peak to trough (PT) and pre-stimulus baseline to peak (BP).

Results: In tinnitus ear, delay of wave III lat was significant. By PT method reduced amp of wave I, III, and increased wave V, III/I ratio, V/I ratio, by BP method increased amp of wave I, III, V, III/I ratio, V/I ratio observed without significance.

Conclusions: In comparison of ABR waveform between ears of unilateral tinnitus patients, there was latency delay of wave III, but no significant amplitude difference was observed.

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