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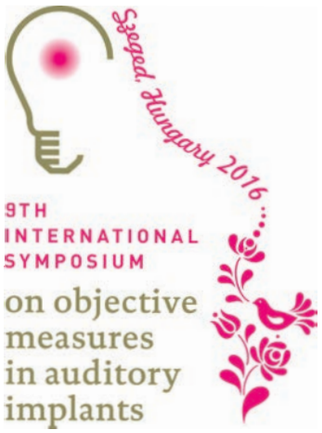

9TH OMAI INTERNATIONAL SYMPOSIUM

ABSTRACTS

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NEW FINDING ABR'S CHARACTER AS A TOOL IN CHILDREN WITH SPEECH DELAY WITH UNKNOWN CAUSE

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Objective: *To determine whether neurophysiological auditory brainstem responses to clicks stimuli differ between typically developing children and children with delayed speech with unknown cause.*

Patients and methods: *We compared the click auditory brainstem responses in 247 children who were clinically diagnosed with delayed speech with unknown cause (case group) based on normal routine auditory test findings a normal neurologic examinations but a more than twelve months speech delay and 179 age and sex matched normally developing children (control group).*

Results: *The case group exhibited significantly higher wave amplitude responses to click stimuli (wave V) when compared to the control group in auditory brainstem responses testing (p=0.001). The significant differences were seen regardless of the age and the sex of the participants. There was no statistically significant difference between two groups considering the latency of wave III or V and wave III amplitude.*

Conclusion: *Early stages of the auditory pathway processing of an acoustic stimulus are not similar in typically developing children and those with delayed speech with unknown cause. Our findings suggest that there are brainstem auditory pathway abnormalities in children with delayed speech with unknown cause.*

SPATIAL HEARING BY EAS-CI AND BILATERAL CI USERS

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Introduction: *Sound azimuth localization of normal-hearing subjects depends on intact binaural processing of ITDs for low-frequency (<2 kHz) and ILDs for high-frequency (>3 kHz) sounds. For CI users is still unclear whether they can gain access to these binaural cues. Several studies demonstrated that not all CI users are capable to localize accurately [1-5]. EAS users might have a better representation of ITDs than CI users and EAS users might use ITD as localization cue (Gifford et al., 2014). In the present study, three particular MED-EL Sonnet cases (1 EAS-CI and 2 BiCI) were tested on their sound localization abilities in a sophisticated setup. Speech in noise and psychophysics tasks were also performed.*

Methods:

- Localization

In this task the subject had to localize sounds presented in a dark, anechoic room by rapid, natural head pointing. Subjects were asked to respond as fast and accurately as possible to the perceived sound location. Broadband (0.4 KHz-10 KHz), high pass (1 KHz) and low pass (0.6 KHz) noise of 150 ms. were presented at 50 dB, 60 dB and 70 dB. The ranges of the frequency bands were selected to stimulate adequately according to their Coding Strategy and device configurations.

- Psychophysics

Via the auxiliary input, absolute ILD detection task for only Envelope and only FSP electrodes (and HA) and absolute ITD detection for FSP (and HA) was tested. A filtered noise burst of 150 ms. was presented and a 2AFC method was applied.

- Speech in noise

The Matrix test method (Houben et al., 2014) was implemented with a lowered frequency adaptation of the International Female Fluctuating Masker (IFFM) (EHIMA, Retrieved 17 April, 2013). SRT scores were analyzed in bilateral and unilateral conditions.

Results: *The psychophysics in ILDs and ITDs Results of all three subjects show that they relay only on ILD cues in high and low frequencies close as normal hearing subjects. ITDs cues cannot be perceived within a range of normal physical time differences. From the localization test it's possible to remark that this subjects are exceptionally good performers. All subjects showed a clear binaural fusion taking into consideration the unilateral localization performance. In accordance to the localization and psychophysical Results, speech in noise performance is also better than the normal average of BICI users.*

Conclusions and discussion: *Primarily, this study reflects the importance of the methodology in the localization task via saccade analysis. From the results it's possible to see the almost normal localization abilities of this subjects. This is hard to find when speakers are visible and the task is not based on a natural response like head pointing. The analysis of all outcomes show clearly the potential benefits of bilateral treatment in spatial hearing and therefore in spatial perception and communication in every day life.*

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RECORDING AUDITORY STEADY STATE RESPONSES IN A PATIENT IMPLANTED WITH THE NEURELECDIGISONIC® SP/SAPHYR® SP COCHLEAR IMPLANT SYSTEM

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The Auditory Steady State Response (ASSR) is a particular auditory evoked potential generated in response to a continuous repetitive amplitude modulation of a carrier tone (1). In hearing participants, the ASSR can be used successfully to objective ly measure the hearing sensitivity, thus constituting a powerful tool for objective audiometry (2). In cochlear implanted (CI) patients, it is more difficult to apply this technique due to the presence of the electrical CI artifact (3). The objective of this study is to propose a new method of CI artifact extraction in the context of ASSR measurements in a CI patient implanted with the Oticon medical/Neurelecdevices.

A 27-year old CI patient participated to the study. A 5-min-continuous 1039Hz tone, amplitude-modulated at a frequency of 39Hz, was presented at 60 dB SPL via the auxiliary cable of the CI processor. EEG data recording was performed with a 32 active electrodes actiCAPand anactiCHamp amplifier.

As a processing step, the Independent Component Analysis (ICA) was applied offline to the raw data to extract the CI artifact. The CI artifact component was clearly identifiable in the data. Results showed that it was then possible to measure the ASSRs.

As a conclusion , ICA can successfully be applied to extract the CI artifact from CI EEG data in the challenging context of ASSR.

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THE UNDERLYING MECHANISM OF PREVENTING FACIAL NERVE STIMULATION BY TRIPHASIC PULSE STIMULATION IN COCHLEAR IMPLANT USERS ASSESSED WITH Objective: MEASURE

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Facial nerve stimulation (FNS) is sometimes observed in cochlear implant (CI) users as an unwanted side effect of electrical stimulation of the auditory nerve (part of N. VIII). FNS is more frequently present in CI users who suffer from otosclerosis or other aetiologies which require above average stimulation levels. The common stimulation applied in current CI consists of biphasic pulse patterns (opposing polarity delivered to intracochlear electrodes with a reference usually placed outside of the cochlear). These pulses induce an electrical field which spreads out in the tissue. If the electrical field broadens as a consequence of higher stimulation levels, the auditory nerve and the neighbouring neural structures become excited. Two common clinical remedies to prevent unpleasant FNS caused by activation of certain electrodes are to expand their pulse phase duration or simply deactivate them. Unfortunately, in some cases these methods do not provide sufficient FNS prevention. This study on 4 subjects with severe FNS compares the impact on FNS of a fitting strategy using triphasic pulses with the impact of the clinical standard fitting with biphasic pulses. The experimental triphasic fitting maps provided by a custom-made speech processor device successfully prevented FNS in all 4 subjects. Electromyographic recordings of the muscles (musculi orbicularis ori and oculi) innervated by the facial nerve were applied to quantitatively assess the effects on FNS. In addition, data of ABI patients stimulated with triphasic pulse pattern are presented. This is, to our knowledge, the first time that objective FNS measures and triphasic pulse stimulation are presented. Based on these recordings, a model is presented which intends to explain the beneficial effects of triphasic pulse application.

ATTENUATION OF NOISE INDUCED HEARING LOSS BY NEAR-INFRARED-LIGHT PRE-TREATMENT

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Nowadays, the protection of residual hearing is one main goal in cochlear implant surgery. Due to similar damaging mechanisms different approaches are investigated for the prevention of noise induced cochlear apoptosis. It could be shown that near-infrared light (NIR) can decrease the cochlear hair cell loss significantly if applied daily after a noise exposure. The present study aimed at investigating the efficacy of a single NIR pre-treatment before a noise exposure.
The cochleae of adult NMRI-mice were pre-treated with NIR-light (808 nm, 120 mW) for 5; 10; 20; 30; 40 or 50 minutes via the external ear canal. All animals were noise exposed for 30 min immediately after the pre-treatment by broad band noise at 115 dB SPL. Frequency specific ABR-recordings were carried out before all treatments and 2 weeks after the noise exposure. One group was noise exposed only and served as control. ABR-thresholds were significantly less elevated two weeks after the noise exposure if the animals were pre-treated by NIR-light. This holds true for 3 frequencies in the "5 min pre-treatment group' and for the entire tested frequency range in all other treatment groups.
Our results suggest that a very effective protection of cochlear structures is possible by a single NIR pre-treatment. A pre-treatment of 10 min seems to be the optimal dosage. The effect was saturated even if higher dosages were applied.
The results could be of high relevance for the protection of residual hearing in otoneurosurgery such as cochlear implantation.
This study was supported by Advanced Bionics GmbH, Hanover, Germany.

USE OF AIDED CORTICAL ASSESSMENT IN PROGRAMMING OF DIFFICULT TO FIT PAEDIATRIC COCHLEAR IMPLANT USERS

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Introduction: *Extensively applicable, objective , fitting methods such as the electrically elicited stapedial reflex threshold (eSRT) method are not always usable. Recording of eSRT may be prohibited by e.g. middle ear fluid, flaccid tympanic membrane or non co-operation. eSRT may also be absent when stimulation is inadequate in CI users with cochlear malformations. Limited evidence based programs can be checked using aided cortical assessment (ACA), program modifications and repeating ACA.*
Objective: *To demonstrate how ACA can be used to make evidence based programming decisions.*
Method: *12 CI users, mean chronological age 40 months, mean hearing age 10 months, 8 with inner ear anomalies/cochlear nerve deficiencies and 4 with normal cochlea were given programs based on cortical response data. Cortical auditory evoked potentials were recorded, in response to speech tokens /m/, /g/ and /t/ representing low, mid and high frequencies at 55, 65 or 75 dB SPL. A PI response to /m/, /g/ and /t/ at 55 dB SPL was targeted. When responses were lacking , increases to maximum comfort level were made in the indicated frequency area (as long as loudness discomfort or non auditory stimulation was not elicited) and ACA was repeated.*
Results: *32 ACAs were done. 6/12 CI users achieved optimum responses. 3/12 had PI responses to /g/ and /t/ at 55 dB SPL and to /m/ at 65 dB SPL. 3/12 had PI responses at 65 or 75 dB SPL.*
Conclusion: *ACA, only requiring passive cooperation, enables clinicians to collect*
Objective: *Data about CI users access to sound.*

USE OF AIDED CORTICAL ASSESSMENT IN COCHLEAR IMPLANT CANDIDACY EVALUATION

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Introduction: *The decision of whether a cochlear implant (CI) benefits a child more than hearing aids (HA) needs to be made promptly to ensure optimal benefit. Information on access to sound and functional hearing can be gathered from aided sound-field testing and questionnaires. Objective, aided cortical assessment (ACA) can be done binaurally or on each ear to collect data to support subjective findings.*
Objective: *To demonstrate how ACA can add useful information to aid CI candidacy decision making and verify improved access to sound with a CI*
Method: *11 children with profound bilateral sensorineural hearing loss, using HAs, with a mean age of 13 months (range 4-24 m) at first fit, had ACA done after a mean of 9 months HA use (range 1st fit to 36 m). PI responses at lowest stimulation levels, 55, 65 or 75 dB SPL, to speech stimuli /m/, /g/ and /t/ were established. 5/11 children subsequently implanted with a CI had ACA done within 5 months of CI use.*
Results: *4/11 HA users had PI responses to /g/ and /t/ at 55 dB SPL. Spoken language development was satisfactory. A wait and see approach was taken to implantation. 3 of the remaining HA users had some PI responses at 75 dB SPL, the other 4 had no PI responses. 5 of these 7 children were subsequently implanted and obtained PI responses to /g/ and /t/ at 55 dB SPL. 2 children are in the process of receiving a CI.*
Conclusion: *ACA provides clinicians with additional objective information.*

VESTIBULAR ASSESSMENT IN CI: HIGH-FREQUENCY HEAD IMPULSE RECORDINGS SUPERSEDES CALORIC IRRIGATION?

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Background: *Previous studies reported variable outcomes regarding vestibular function when caloric irrigational electro- or videonystagmography were used. To what extent conventional irrigation as an objective tool to assess specific postop clinical symptoms is not yet clear. Recently, a modern version of the 'head thrust test' is applied to assess the vestibulo-ocular reflex (VOR), using high-resolution (i.e. with a sampling frequency >100 Hz) video-Head Impulse Test recordings (vHIT). However, its clinical application for the assessment in CI subjects is still limited.*
Aim: *To evaluate (patient-friendly) goggle-less video-Head Impulse Test (vHIT) in CI adults and children (pre- and postoperatively) and compare its sensitivity with conventional electro-nystagmographical responses evoked by caloric irrigation, as well in relation to clinical symptoms.*
Results: *ENG data were not in conformity with clinical symptoms. Subjective data (DHI) did not support the objective caloric data. However, vHIT responses show high sensitivity in diagnosing uni- or bilateral vestibular loss, is able to also assess vertical semicircular canals, show more consistency and higher response rates. In those cases where it was possible to obtain reliable caloric data, vHIT responses were in agreement with conventional measurements in more than 85%.*
Conclusion: *Although many studies report vestibular loss after CI based on caloric data, one has to realize that Conclusion s based on just caloric data might overestimate vestibular degradation due methodological constraints. vHIT has the advantage that it better reflects the 'daily life' (frequency range), although the exact role of otoliths for compensation or degradation is also not yet known.*

DECONVOLUTION OF SPREAD OF EXCITATION CURVES: TOWARDS IDENTIFICATION OF THE EXCITATION AREA

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Introduction: *Based on the electrically evoked compound action potential (eCAP), spread of excitation (SOE) curves can be measured. SOE curves are usually measured by forward masking (FM) and show the interaction between masker and probe stimuli. To retrieve the excitation areas attributable to either masker or probe, SOE curves can be processed into excitation density profiles (EDPs) using deconvolution (1). These EDPs represent the excitation area for individual stimuli. It is expected that lower stimulus intensities excite smaller neural regions, however, this could not be derived from the SOE curve itself.*
Objective: *To investigate the relationship between stimulus intensity, eCAP-based SOE and EDP*
Patients & methods: *ECAP-based SOE curves were measured in 21 patients (13 intra- and 8post-operatively), implanted with a HiRes90K (Advanced Bionics). The curves were recorded on electrodes 3-16 using FM and deconvolved into EDPs. In addition, SOE curves were measured with varying probe stimulus intensity and combined with calculated masker EDPs to compute the EDPs for different probe stimulus intensities.*
Results: *Lower probe intensities lead to a decrease in SOE curve amplitude while the width of the curve does not change noticeably. However, deconvolution reveals that lower stimulus intensities induce narrower EDPs, as determined by the 50% density level, as well as a decrease in area under the EDP.*
Conclusion: *With the deconvolution method it can be demonstrated that lower stimulus intensities cause smaller excitation areas. This is in line with the expectation that lower stimulation intensities are more selective.*

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CAN YOU HEAR THE DIFFERENCE? EEG-BASED SINGLE-TRIAL DEVIANT DETECTION IN COCHLEAR IMPLANT USERS

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Cochlear implants (CIs) are devices that restore hearing to the profoundly deaf. However, certain patients are unable to provide feedback necessary for optimal fitting of their CI. Objective measurement procedures can help to improve CI fitting for such patients. A possible basis for objective fitting is the electroencephalogram (EEG). The EEG contains components related to sensory and cognitive processing of acoustic stimuli. In an oddball paradigm the EEG reveals different neuronal responses to rare deviants in a stream of frequent standard tones, if the difference has been heard by the participant. However, clear distinction typically requires a large amount of averaged repeated stimuli.
Our work focuses on reducing the amount of repetitions required for deviant detection to only one trial. In particular, we perform deviant detection with single-trial classification, which was developed in the field of brain-computer interfaces.
We analyzed EEG data from 9 CI-users who participated in an auditory oddball paradigm with intensity and frequency deviants. The amount of deviation was individually adjusted based on the participant's just-noticeable-difference. Deviant detection was performed with shrinkage linear discriminant analysis on spatio-temporal features.
Average deviant detection rate varied greatly between participants (mean: 69%, SD: 6%, min: 60%, max: 76%), but was significantly higher than chance level (p95=58%) for all participants.
While single-trial classification works very well in some users, detection rate is low in others. This can be improved by using more than one trial. In summary, EEG classification is a promising approach for acoustic deviant detection in CI-users.

WORKING MEMORY CAPACITY AND ITS INFLUENCE ON HEARING IN COCHLEAR IMPLANT USERS

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The aim of the study was to investigate the influence of working memory load on auditory distraction. We recorded the electroencephalogram (EEG) of cochlear implant (CI) users and age-matched normal hearing (NH) participants during an n-back task. Working memory (WM) load was manipulated by n-back task difficulty. We were interested how event-related potentials (ERPs) in response to distractor sounds and visual task stimuli change depending on participants' WM load and whether we find dissociable load-induced ERP modulations in CI users and NH participants. We presented visual numbers and participants had to compare the presented number either to the previous (1-back) or to the previous to last number two turns back (2-back). In the easiest condition, the participant had to decide if the number was odd or even. We presented auditory distractor stimuli during visual inter-stimulus intervals which could be frequent standards or novel sounds (25%). Preliminary behavioral results indicate slower and less accurate responses to visual stimuli in the higher load conditions. Preliminary ERP results suggest reduced auditory distractibility in higher WM load conditions. We hypothesize that auditory ERPs in CI users are delayed and that these individuals show stronger distraction effects in task-related visual ERPs. The present study provides new evidence on how WM and cognition is related to CI performance and the results will be discussed in the context of CI rehabilitation.

USE OF ELECTRICALLY EVOKED COMPOUND ACTION POTENTIALS FOR COCHLEAR IMPLANT FITTING, A SYSTEMATIC REVIEW

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Background: *Over the last decade, objective fitting of cochlear implants has become readily available in clinics, possibly eliminating the need for time-consuming behavioral fitting procedures. Although fitting based on electrically Evoked Compound Action Potentials (eCAPs) has been studied extensively, there is no clear consensus in literature about the validity of this procedure.*
Objective: *To compare the suitability of objective eCAP data for fitting purposes with behavioral data.*
Methods: *The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method was used. The databases searched were PubMed, Web of Science and the Cochrane Library. The term 'eCAP' was combined with 'cochlear implants', 'thresholds' and 'levels' with addition of a range of related terms. Finally, 36 studies were included which were evaluated based on Risk of Bias.*
Preliminary results: *All assessed studies suffered from some form of Risk of Bias: only 2 studies had separated individual subject data from grouped results ,13 studies were unclear about randomization and/or blinding, 3 studies had a very small number of subjects (<10),21 studies provided no clear distinction between populations used (i.e. pre- and postlingually implanted subjects) and 7 studies had a high number of loss (>10%) in patients and/or electrodes, causing an attrition bias.*
Conclusion: *Because nearly all studies used grouped data, small numbers and unclear populations, they introduced a high Risk of Bias. Therefore, a funded conclusion about the validity of the use of objective measures for individual fitting cannot be made based on the currently available literature.*

ELECTROCOCHLEOGRAPHY FOR MONITORING OF RESIDUAL HEARING DURING AND AFTER COCHLEAR IMPLANTATION

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Electrocochleography (ECochG) has a long history of diagnosis of the auditory system. With an increasing number of patients showing significant residual hearing being provided with a cochlear implant, ECochG is becoming also interesting for CI users to monitor residual hearing during and after the implantation.
In this study, 20 subjects with residual hearing shall be implanted with the HiFocus MidScala electrode array by Advanced Bionics. During the insertion ECochG shall be recorded from intracochlear electrode contacts. From the recorded signal, cochlear microphonics shall becomputed, averaged and transformed to the frequency domain. By comparing the amplitude at stimulus frequency to the noise floor of the measurement, the hearing threshold can be estimated. Due to the short distance between the potential`s origin and recording site, only few averages are required resulting in arecording time of 1-2 seconds. That almost allows for real-time feedback during the insertion of the electrode into the cochlea. If the threshold is dropping, the surgeon might have the possibility to correct the course of electrode insertion.The subjects will be coming back to the clinic in regular intervals after surgery to conduct further ECochG recordings via the implant system.

So far, the measurement procedure has been tested and refined; pilot measurements were done. These have proven the feasibility of fast measurements during the insertion. In conclusion, the measurement of ECochG might be used as an intraoperative tool supporting atraumatic insertion of the electrode array.

WIRELESS ABR MEASUREMENTS VIA MINI TEK&VIBRANT SOUNDBRIDGE WITH DEVICE OPTIMIZED CHIRP STIMULUS

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Objective measurements are not routinely used for estimating the performance of active middle ear implantsystems. Furthermore, it can be very helpful to have a method available assisting the implantation process in difficult situations like positioning of the acoustic transducer. Promising methods are based on auditory brainstem response (ABR). Resent years high performance ABR systems have been developed using optimized chirps stimuli. To maintain the performance of such measurement systems it is necessary to compensate any distortion of transducers. The purpose of this study is to provide an optimized chirp stimulus for using with the miniTek™ (wireless streamer, Sivantos) & Vibrant Soundbridge™ (VSB, MED-EL). The ABR measurements were done with IA Eclipse™ system (EP25, experimental module). By using the traveling wave delay model of the integrated broadband CE-Chirp, a new chirp stimulus was constructed considering the group delay of the miniTek& VSB system (VORP 503 with Samba audio processor). The verification of the new stimulus was done by measuring the output signal of the miniTek&VSB system. It is evident that the reconstructed chirp stimulus follows the model function of the CE-Chirpmuch closer than uncompensated. First ABR measurements in VSB patients demonstrate a better performance of the device'soptimized chirp stimulus.

EVALUATION OF THE CURRENT DISTRIBUTION OF THE HYBRID COMMON GROUND STIMULATION IN COCHLEAR IMPLANTS

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Background: *In cochlear implants, the hybrid common ground is a combination of a classic monopolar stimulation with a standard common ground. This new stimulation montage allows the current to return from both the non-stimulating electrodes on the electrode array and the reference electrode placed between the skull and scalp. In theory, this lead to reach a compromise between the current focality and the efficiency of the stimulation. Even if this stimulation type has already been adopted by some implant manufacturers, the 3D geometryofits current pathways remains to be studied.*
Methods: *The study is two-fold. First, an in-vitro experiment aimed to measure the electrical field produced by the hybrid common ground stimulation. An electrode array of an XP implant (Oticon Medical, Neurelec) was placed in saline solution and the electrical field was recorded by a probe that moves along the programmed grid. During the stimulation, the current waveforms on all the grounding electrodes were also recorded. Second, an in-situ measurement was conducted. Another XP device was implanted into a human specimen. The same procedure as in the in-vitro measurement was performed to record, this time, the current wave forms only.*
Results: *The recorded two groups of current data were compared with each other to investigate how the current path is modified by the geometry of a human cochlea. The potential distribution measured during the in-vitro experiment was also compared with other stimulation types such as monopolar. The energy consumption of the stimulation was also computed from the collected data.*

BEHAVIOURAL AND ECAP MEASURES OF TEMPORAL PROCESSING IN COCHLEAR IMPLANT LISTENERS AT SWITCH-ON AND 2 MONTHS LATER

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It is well-established that cochlear implant (CI) listeners are poor at perceiving pitch from the pulse rate applied to one or more electrodes. For most listeners there is an upper limit, whereby increases in pulse rate above 300 pps do not produce increases in pitch. There is physiological evidence from animals that, after a long period of deprivation, inferior colliculus neurons phase lock only to low-rate pulse trains, and that this limit can be increased after long-term experience of electrical stimulation. It is possible that a similar phenomenon occurs with CI listeners, and that this leads to an increase in the upper limit of pulse-rate pitch.
These experiments measured rate pitch discrimination using direct stimulation of a single electrode in a group of nine CI listeners. Initial measures were at the 'switch-on' appointment (less than 15 mins of stimulation), and were repeated after 2 months of use with the clinical speech processor. We hypothesized an increase in the upper limit of rate pitch, as revealed by a pitch ranking task using rates from 120 to 980 pps, from session 1 to session 2. A smaller or absent improvement was predicted for discrimination of rates centred on 120 pps, which relies on slower temporal processing. Effects of practice and of long-term stimulation were quantified by comparing with-in session and across-session performance changes. Additionally, ECAP measures of auditory nerve recovery were measured at the same time points, and, where possible, compared to behavioural data.

THE ACCURACY OF ELECTRICALLY EVOKED COMPOUND ACTION POTENTIAL THRESHOLD MEASUREMENTS

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Introduction: *The electrically Evoked Compound Action Potential (eCAP) threshold is commonly determined by linear extrapolation; alternatively, a sigmoidal extrapolation can be used. The accuracy of the threshold, as expressed by the Threshold Confidence Interval (TCI) is not only dependent on the actual measurement error or Random Error (RE), but also depends on the accuracy of the fit.*
Objective: Comparison of the accuracy of linear and sigmoidal extrapolation methods to determine the eCAP threshold in terms of RE and TCI.
Methods: *Twenty-one Amplitude Growth Functions (AGFs)were repeatedly measured in 14 HiRes 90K (Advanced Bionics) CI recipients. TheRE for linear and sigmoidal fits was calculated and correlated with the TCI calculated for both extrapolation methods.*
Results: *The RE of sigmoidal was significantly smaller than that of linear extrapolation (47 μA vs. 178 μA; p=0.009), but the calculated mean width of the TCI was not (174 μA vs. 224 μA; p=0.12). Standard deviations were significantly smaller for sigmoidal extrapolation (TCI 0.06, RE 0.02) than for linear extrapolation (TCI 0.21, RE 0.22).*
For linear extrapolation there was a significant correlation between the TCI and RE (r=0.61; p=0.005). This was not the case for sigmoidal extrapolation (p=0.27).
Conclusion: *The use of sigmoidal extrapolation shows a narrower TCI and a smaller RE than the linear equivalent. Also, the variation in spread of TCI and RE is much smaller for sigmoid extrapolation. Therefore, the sigmoidal extrapolation method is more accurate, and provides a more reliable threshold prediction for cochlear implant fitting.*

INTRA-OPERATIVE ASSESSMENT OF DIRECT ACOUSTIC COCHLEAR IMPLANT FUNCTIONING USING ABRS AND ASSRS

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Introduction: *Direct Acoustic Cochlear Implants (DACIs) are used to treat severe to profound mixed hearing loss. An actuator in the middle ear is coupled via a stapes prosthesis to the inner ear, and directly vibrates the cochlear fluid. Confirming proper DACI coupling, crucial for its functioning, is challenging for ENT surgeons. Currently, the movement of the actuator is verified intra-operatively using Laser Doppler Vibrometry (LDV), requiring specific technical skills. Furthermore, LDV movement measures at the actuator rod do not confirm correct DACI coupling or adequate auditory processing. Electrophysiological responses have recently been recorded post-operatively in DACI subjects (1) and could potentially also be used to assess DACI coupling intra-operatively.*
Objective: *To use auditory brain stem (ABRs) and steady-state responses (ASSRs) intra-operatively to confirm correct DACI coupling and evaluate auditory processing beyond the periphery.*
Materials/Patients and Methods: *ABRs and ASSRs were measured in two subjects under general anesthesia. Click stimuli were presented directly to the implant*

with stimulation frequencies in the 40 Hz and 90 Hz range at various stimulation levels. Electrophysiological thresholds were determined and compared with the behavioral thresholds obtained after DACI activation.

Results: *For stimulation in both frequency ranges, clear ABR peaks V were observed and ABR thresholds could be estimated. Significant steady-state responses were measured for 33 Hz stimulation and for 90 Hz stimulation, allowing electrophysiological threshold estimation.*

Conclusion: *The feasibility of measuring electrophysiological responses beyond the periphery intra-operatively to confirm DACI coupling has been demonstrated.*

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OBJECTIVE MEASURES FOR DEVICE FITTING AND CODING STRATEGY OPTIMIZATION

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Coding strategies for cochlear implants describe how sound signals have to be converted into spatio-temporal current pulse patterns which are transmitted to the nervous system via stimulation electrodes. Patient-specific parameters of these coding strategies such as the range of stimulation levels for individual electrodes have to be determined using behavioural audiometric test procedures, objective electrophysiological measures or combinations of the two approaches. Electrically evoked compound action potentials (ECAPs) have recently been shown to be particularly useful and easily applied in the clinical environment.

In addition to assist in device fitting, objective measures may also provide important information for the optimization of novel bioinspired coding strategies. Traditional strategies were based on properties of the acoustic signals and concepts developed originally for communications systems. Implant-specific constraints such as current spread and limited electrical dynamic range were addressed by various Methods: However, the detailed capacity of electrically stimulated groups of neurons for optimal information transmission has rarely been considered in practical applications. Rate dependent neural adaptation properties observed for stimulation rates up to several hundred pulses per second as well as amplitude variations within pulse train stimulation of rates up to several thousand pulses per second point to the importance of improved neural excitation models.

Several variations of an excitability controlled processing model were integrated into a coding strategy and evaluated in pilot experiments with CI recipients. Objective measures for amplitude growth, recovery functions, spread of excitation and pulse train responses may help to optimize the processing algorithms.

SPEECH INTELLIGIBILITY AND VERBAL ABILITIES IN COCHLEAR IMPLANT USERS – WHAT WE CAN LEARN FROM Objective: MEASURES

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The aim of this study was to investigate how verbal abilities relate to speech understanding in cochlear implant (CI) users and single-sided deaf (SSD) CI users. We studied different central-auditory processes underlying speech perception by using electroencephalography. We recorded the participants' EEG during an auditory oddball task. In this task participants were asked to press a button every time they heard a rare target word (20%) intermixed in frequent standard words. We collected data from CI users and matched normal hearing (NH) participants. For these two subgroups the words were presented in quiet and noise. SSD CI users enabled us to compare the neuronal processing underlying speech perception with a CI and NH intra-individually in quiet. Additionally, we assessed the participants' lexical fluency, verbal working memory, and word recognition.

Behavioral responses were overall slower and less accurate when words were presented via the CI compared to NH. These behavioral findings go in line with the ERP results, showing longer ERP latencies at higher-level processing stages (N2, P3 component). This holds true for the CI users compared to the NH participants and for the CI ear compared to the NH ear in SSD CI users. We observed group specific effects of background noise on ERP responses for the CI users group compared to the NH group. Finally, we found relationships between speech intelligibility, behavioral responses in the oddball task and verbal abilities. These results show a complex interplay between word recognition ability, verbal abilities, and neural processing of spoken words.

EFFECTS OF UNILATERAL HEARING LOSS ON SPEECH IN NOISE COMPREHENSION MEASURED WITH FUNCTIONAL IMAGING

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Background: *Corticalregions activated in unilateral hearing loss (UHL) when processing degraded speech are unknown. In normal hearing (NH) high, moderate, and low levels of speech degradation parametrically modify response amplitudes in non-auditory left inferior frontal gyrus (IFG) and angular gyrus (AG). Individuals with UHL have diminished perceptual abilities and often listening in noises effortful. In this study we determined whether in UHL compensating for speech processing deficits when listening in noise similarly engage non-auditory cortical regions previously noted in NH. We need knowledge of the effects of UHL and proposed treatment options, especially as cochlear implantation for UHL is increasingly considered.*

Method: *Age and gender matched adults were either UHL in the right ear or NH. During fMRI scans participants noted the semantic predictability of sentences from the Revised Speech Intelligibility in Noise test in which contextual information affected low and high predictability. Sentences were variously degraded by noise vocoding with 4, 8, or 16 filter bands. Using echo planar sequences with 4 mm^3 resolution, BOLD responses were captured during 2s volume acquisitions in 9s interrupted trials.*

Results: *Preliminary results showed similar activated cortical regions in each group. Significant activity occurred in bilateral superior temporal gyrus/sulcus, auditory/speech regions, which was slightly lower in left cortex of UHL. Activation extent in left hemisphere IFG and AG followed an inverted U-shape in both groups to the three degradation levels, but was significantly less in UHL.*

Conclusion: *Individuals with UHL engage non-auditory cortex but to a lesser extent than NH.*

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MEASUREMENT OF RESIDUAL COCHLEAR PHYSIOLOGY USING ELECTROCOCHLEOGRAPHY: CORRELATIONS WITH SPEECH PERCEPTION OUTCOMES IN ADULTS AND CHILDREN

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Introduction: *Reasons for the high variability in cochlear implant speech perception outcomes are generally lacking. A major factor may be the cochlear and neural physiology at the time of implantation. Electrocochleography (ECochG) from the round window to auditory stimuli can assess the state of the cochlea prior to implantation.*

Objective: *Correlate cochlear physiology with speech perception outcomes.*

Methods: *Subjects are adults and children receiving cochlear implants. ECochG at the round window to tones was used to characterize cochlear physiology. Speech perception outcomes were CNC word scores at 6 months for adults, and PBK word scores at 4-5 years old for children.*

Results: *Adults and children were similar in terms of the potentials recorded. In both groups responses were obtained from nearly all subjects, there was huge variation (>60 dB) in response magnitudes across subjects, and the responses were primarily to frequencies of 1000 Hz or less. In most adults the ECochG-TR accounted for >40% of the variability in speech perception outcomes at 6 months post-implantation, in children implanted at >3 years the ECochG results accounted for >30% of the variability, while in children implanted at <3 years the ECochG accounted for less than 20% of the variability.*

Conclusion: *The difference between adults and the youngest children undoubtedly has many causes, including a lack or prior knowledge of speech and the high variability in use and training in children. However, a major cause may be the large difference in the reasons for deafness in the groups.*

MONITORING COCHLEAR PHYSIOLOGY USING EXTRACOCHLEAR ELECTROCOCHLEOGRAPHY DURING IMPLANT INSERTION

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Introduction: *Reducing trauma to the cochlea during implant surgery can be expected to improve hearing preservation and speech perception outcomes. As a means to assess whether trauma is occurring, electrocochleography (ECochG) from the promontory to acoustic stimuli was used.*
Objective: *Use ECochG to monitor cochlear physiology during implant surgery as a means to monitor and reduce surgical trauma.*
Methods: *Subjects were adults and children receiving MED-EL cochlear implants. Cochlear physiology before, during and after insertion was monitored using ECochG from the promontory to 500 Hz tone bursts at 90 dB nHL. No feedback to the surgeon was given in this study.*
Results: *Insertions produced either:*
1) no loss of ECochG response at any point, suggesting an atraumatic insertion,
2) reductions in responses during insertion followed by recovery, suggesting temporary fixation of the basilar membrane not associated with trauma, or
3) reductions in response that did not recover by the end of the insertion, suggesting cochlear trauma occurred.
Conclusion: *Acoustic responses can be usefully monitored from an extracochlear location during insertion of the implant. The presence of response reductions not indicative of trauma needs to be further explored and characterized before the technique can yield timely information about ongoing trauma.*

EVALUATION OF ECAP THRESHOLDS DERIVED FROM AMPLITUDE GROWTH FUNCTIONS

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Introduction: *An amplitude growth function (AGF) shows the amplitude of the electrically evoked compound action potential (eCAP) as function of stimulation current. These AGFs can be used to derive the eCAP threshold, which represents the minimum amount of current needed to elicit a measurable eCAP. Clinically, eCAP thresholds have been widely used, e.g., to assist with sound processor programming. However, it has never been investigated how accurate these thresholds are.*
Objective: *To investigate the accuracy of the eCAP threshold and its consequence for clinical practice.*
Patients & methods: *663AGFs of 135 patients, all implanted with a HiRes90K (Advanced Bionics), were analysed. For each AGF, the eCAP thresholds and its confidence interval (TCI) were determined using both linear extrapolation (LE) towards the x-axis and automatic detection of the last visible (LV) eCAP.*
Results: *ECAP thresholds estimated with LE are systematically smaller than that estimated with LV, and TCIs of LE are larger than that of LV (188±144 CU versus 50 CU). The LE thresholds with smallest TCIs correlate best with LV thresholds. Across all patients, the subjective threshold profile (T-level) fell within the TCIs of the objective thresholds. For individual patients, no significant correlation was found, neither between T-levels and LE thresholds ($p=0.42\pm0.31$), nor between T levels and LV thresholds ($p=0.34\pm0.32$).*
Conclusion: *The methodology used to measure and analyse eCAPs has substantial consequences for the reliability of eCAP (threshold) in clinical practice. Therefore, an analysis of accuracy has to be included in future research on eCAP thresholds.*

NON-LINEAR BEHAVIOR OF THE AMPLITUDE GROWTH FUNCTIONS OF ELECTRICALLY EVOKED COMPOUND ACTION POTENTIALS AT HIGHER STIMULATION LEVELS

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Introduction: *Amplitude growth functions (AGF) of electrically evoked compound action potentials (ECAP) in cochlear implant (CI) users often show a non-linear behavior both, close to threshold as well as close to the upper limit of the dynamic range. Typically those non-linear parts of the AGF areneglected in the further analysis and are not investigated any further. This analysis focusses on the non-linear behavior close to the upper limit of the dynamic range.*
Objective: *To discuss potential explanations for non-linear behavior of the ECAP AGF.*
Method: *ECAP amplitude growth functions were recorded in 18 Advanced Bionics CI users using RSPOM (Research Platform for objective Measures). Four electrodes (typically electrodes 2, 6, 10, 14) were stimulated using alternating polarity with a pulse width of 32µs. Additional pulse widths between 11 µs and 75 µs were measured depending on the loudness at compliance limit. Below compliance limits AGFs were measured up to the loudest acceptable level.*
Results: *147 AGF measurements were available for further analysis. 80 of them showed a deviation from the linear growth in the upper dynamic range. Only in 20 recordings this deviation was at or above the compliance limit of the current source, calculated based on impedance measures. When comparing recordings at various pulse widths in only 20 out of 31 recordings the deviation from linear growth decreases with increasing pulse width.*
Conclusion: *The compliance limit of the stimulating current source calculated from impedance measures is not sufficient to explain non-linear behavior of the AGF for high stimulation levels.*

OBJECTIVE ASSESSMENT OF STREAM SEGREGATION ABILITIES OF CI USERS AS A FUNCTION OF ELECTRODE SEPARATION

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Auditory streaming is a perceptual process by which the human auditory system organizes sounds from different sources into perceptually meaningful elements. Segregation of sound sources is important, among others, for understanding speech in noisy environments, which is especially challenging for cochlear implant (CI) users. Despite its high relevance in many daily situations, the amount of studies investigating streaming abilities of CI listeners is fairly limited and their findings are contradictory. It is unclear whether CI users are able to experience stream segregation as a function of electrode separation and whether this is perceived to occur instantaneously or to build-up over time. The present study objective ly assesses stream segregation abilities of CI users as a function of electrode separation and aims to establish whether perceived stream segregation needs time to build-up. CI users participated in an objective rhythm detection task composed of sequences of interleaved A and B tones, with frequencies allocated to different electrodes. The subjects were asked to indicate whether they could detect a deviant in the rhythm of the otherwise regular B tone stream. The A-tone stream was jittered, making time judgments between the A and B tone streams an unreliable cue to perform the task. Thus, segregation of the streams would improve performance. The electrode separation and the duration of the sequences were varied between trials. Preliminary results show that performance increases with electrode separation and sequence length, suggesting that CI listeners experience stream segregation as a function of electrode separation and that this percept builds-up over time.

COCHLEA HEALTH MEASUREMENTS TO SHOW THE EFFICIENCY OF STEROID TREATMENT DURING COCHLEAR IMPLANTATION USING A COCHLEAR CATHETER

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Introduction: *In cochlear implantation the insertion trauma and the inflammatory process may deteriorate residual hearing. Applying steroids are commonly used to prevent these adverse effects. Different application methods are used like a systemic delivery or a local application at the round window. Recently, a Cochlear catheter (CC) was developed by MED-EL (Innsbruck, Austria) to apply steroids directly into apical regions of the scala tympani prior to electrode insertion.*
Objective: *Animal studies show that a change in neuronal density of the auditory nerve can be verified by objective measurements. Here, especially the amplitude growth function (AGF) of ECAP measurements is an indicator for the cochlear health (1, 2). We hypothesize that this is also observable in patients with cochlear implant (CI).*
Materials & methods: *In a first step, a data base is being created by retrospectively analyzing the ECAP slope for each of the 12 electrodes of the cochlear elec-*

trode array. The data were measured routinely during postoperative follow-up appointments of the CI patients at our clinic. Further, the measurements are categorized and evaluated for the duration of deafness and different electrode lengths. In a second step, patients with and without treatment with steroids via the CC will be compared.
Results: *In establishing the data base, preliminary results from 268 patients show an increase in ECAP slope from the base to the apex from 17 to 51 µV/nC. So far only few patients have been treated with the CC. The study is ongoing. Newest results will be presented.*
Conclusion: *In investigating the possibility of using ECAP measurements to predict cochlear health, a data base was established. Further measurements are necessary.*

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INFLUENCE OF STIMULATION INTENSITY ON FIRING PROPERTIES OF ECAP RESPONSE ASSESSED USING A FINE-GRAIN RECORDING PARADIGM AND CONVOLUTION MODEL

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Introduction: *The electrically evoked compound action potential (ECAP) is a routinely performed objective measure of the auditory nerve. The morphology of the waveform is rarely analyzed despite its potential to contain information on the firing properties of the auditory nerve for electrical stimulation.*
Objective: *Single ECAP waveforms were recorded using a fine-grain recording paradigm where the stimulation intensity was increased in quasi-continuous steps until the loudest acceptable presentation level. Each ECAP waveform was analyzed by deconvolving it into its single fiber response and its compound discharge latency distribution (CDLD).*
Results: *ECAPs were recorded in 35 MED-EL CI users (39 implants) over the full electrode array using a fine-grain paradigm which resulted in on average 253 different stimulation levels. The CDLD for each ECAP waveform was derived numerically via deconvolution and in most cases could be parameterized by two Gaussian distributions with an average latency difference of 0.4 ms. At low stimulation intensities, the later component showed a larger contribution to the ECAP waveform. With increasing stimulation intensity an increased contribution of the earlier component was observed.*
Conclusion: *Analyzing the morphology of the ECAP waveform via a convolution model has the potential to give further insight into the underlying mechanisms of the electrical stimulation. In particular it revealed two separate firing components in the auditory nerve with varying contribution depending on the stimulation intensity.*

FINE-GRAIN ART STUDY

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Introduction: *In patients with a cochlear implant (CI), electrically evoked compound action potentials (ECAPs) have become an important measure for fitting and to show proof of correct location of the electrode array. In a standard clinical setup, recordings of ECAPs are averaged over 25 to 100 repetitions to allow the detection of an ECAP within the noise floor. To obtain an amplitude growth function (AGF), these measurements are normally performed for 5 to 10 different stimulation levels. The stimulation level resulting in a maximal acceptable loudness percept is normally unknown and needs to be obtained behaviorally during the measurement.*
Objectives: *We want to extend the recording paradigm routinely performed to acquire ECAP AGFs to allow for an improved assessment of the status of the electrode-nerve interface. Furthermore we want to reduce the clinically relevant total recording time and in parallel improve the possibility of the CI user to behaviorally feedback when a maximal acceptable loudness is reached.*
Materials & methods:*Our study group comprises 35 CI users with MEDEL implants. We present a new ECAP recording paradigm of the Auditory Nerve Response TelemetryTM , "fine-grain ART", where the stimulation intensity is increased in quasi-continuous steps and instead of averaging repeated recordings with identical stimulation parameters, running averages over small intervals of stimulation levels are computed. The first visible ECAP within an AGF was manually identified by an expert and a sigmoidal model was fitted to the measured AGF.*
Results: *AGFs were recorded within 39 ears using the new proposed ECAP recording paradigm as well as the above described standard clinical procedure. All subjects could reliable indicate when the maximal acceptable loudness was reached. The intra-subject difference between the first visible ECAP response and the ECAP threshold derived from the fitted sigmoidal AGF model were evaluated for the two paradigms, as well as the total recording time needed to obtain an ECAP threshold. The difference in ECAP threshold comparing the standard and the fine-grain approach were negligible. The recording time per electrode channel until ECAP threshold was reached was considerably lower with the new fine-grain approach.*
Conclusion: *The new fine-grain ART paradigm leads to comparable results regarding ECAP threshold than the standard clinical approach. In addition it can also reveal the fine-structure in the amplitude growth function. This could give valuable information in respect of the responding neurons and speech processor adjustments.*

ESTIMATING COUPLING EFFICIENCY OF VSB MIDDLE EAR IMPLANT SYSTEM USING ABR/ASSR METHODS

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The Vibrant-Soundbrige™ (VSB) is an active middle ear implant that is surgically coupled to different structures in the middle ear, depending on the type of hearing loss and the individual physiology of the middle ear. Hearing improvement is highly dependent on the coupling efficiency between the FMT and the middle ear structure. Especially in patients with a bone conductive hearing loss of 30 dB HL and higher an efficient coupling is necessary to achieve adequate hearing results and avoid revision surgeries. Currently there is no sufficient method to determine the coupling efficiency intraoperatively. For this application we intraoperatively measured auditory brainstem responses (ABRs), while stimulating the patient via the implant. For this purpose awireless streamer (SivantosMiniTek™) was used to transmit stimuli from the ABR system via the audio processor (Samba™) to the FMT of the implant. The ABRs were evoked by chirp-sounds, using the broadband CE-Chirp as well as octave bandchirps starting from levels above bone conduction threshold to levels below threshold.
For this study, we evaluated ABRs in VSB patients on a single patient basis. The ABR-thresholds were related to bone conduction thresholds and to the vibrogram to verify this new method. Overall, ABR measurements via VSB are able to determine the coupling efficiency between the FMT and the middle ear structure. As a future aim, developing an automated system, that uses ASSR to give only a 'pass' or 'fail', without any subjective judgement from an audiologist is intended.

CORTICAL AUDITORY EVOKED POTENTIALS IN CI USERS

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Background: *Cortical Auditory Evoked Potentials (CAEP) is a measure of the structural integrity and functionality of the auditory system. This objective method can be used even in patients with poor cooperation in behavioral assessment of hearing.*
The aim of this study was to compare CERA results in CI patients after different periods of time of CI experience.
Method: *We evaluated 5 subjects (MED-EL adult CI users) after activation, at 3 and 6 months after initial fitting. All of them were submitted to behavioral assessment of hearing (free field speech audiometry) and electrophysiological evaluation of central auditory system (measurement of CAEP).*
Results: *Comparison included presence versus absence of CAEP and speech audiometry results in same subject (cross-validation of the methods), as well as differences in latencies and amplitude of CAEP for the three measurements.*
Conclusion: *We consider CAEP a good objective tool for assessment and monitoring of the auditory benefit in CI users.*

CHRONIC ANIMAL MODEL OF COCHLEAR IMPLANTATION IN GUINEA PIGS: INTERESTS AND APPLICATIONS FOR COMPARISON OF LOUDNESS CODING USING PULSE AMPLITUDE OR PULSE DURATION

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Background: *The effect of electrical pulse shapes on electrophysiological and behavioral responses are still providing major investigations for improving coding strategies of cochlear implanted (CI) users. The present study aims to record evoked potential from a chronic animal CI model stimulated with a dedicated Animal Stimulation Plateform (ASP). Two different approaches to code loudness were used: by modulating either the amplitudes or durations existing in each pulses in the electrical pulse train. Those two strategies were compared by using the electrically evoked compound action potential (eCAP) and electrically evoked Auditory Brainstem Responses (eABR) collected simultaneously in chronically implanted guinea pigs.*
Methods: *Six guinea pigs were implanted with 6-electrodes, dedicated electrode-arrays. The connector was secured on the head of the animal using dental cement and the stimulation was controlled via the ASP (Oticon Medical, Neurelec). Measurements were done for 20 increments either in pulse-amplitude and pulse-duration. Amplitudes and latencies characterizing eCAPs or eABRs responses were automatically analyzed.*
Results: *ECAP and eABR growth functions expressed in terms of the pulse charge injected showed different patterns in function of the loudness strategy used. These patterns were consistent across subjects and across time after implantation. The duration loudness coding strategy showed steeper eABR and eCAP growth functions than amplitude increments.*
Conclusion: *The ASP provided an efficient way to measure animal's eCAP and eABRs and lead to a first experimental application. Data collected suggested that the pulse duration loudness coding remains to be a valuable strategy to mimic a growing sound level.*

ARE SPREAD OF EXCITATION AND NEURAL RESPONSE REFRACTORY TIME INFLUENCED BY ELECTRODE ARRAY TYPE?

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Introduction: *The inter-electrode distance and the distance from the electrode to the ganglion cells may interfere in the nerve fibers recruitment revealed by the spread of excitation and the recovery function.*
Objective: *The primary goal of the study was to determine whether the spread of excitation (SOE) width and recovery function (REC) parameters are influenced by the type of electrode array.*
Design: *Retrospective chart review of 300 intraoperative recordings of children and adults implanted with Nucleus® devices, collected from a mid-array electrode (11 or 10), that were considered for analysis. The SOE series was recorded through the electrical compound action potential at a constant current level above the threshold as a function of the masker electrode, while the REC function was recorded as a function of the masker probe interval, at the same current level, through the Custom Sound® EP software. The type of electrode array was collected from patients´ files, and statistical analyses were performed to examine both SOE width and REC parameters.*
Results: *Adults showed SOE widths and refractory periods statistically different from children. SOE width significantly differed in patients with the full-banded straight arrays. For the REC parameters, no differences were foundamong type of implant, except for a longer tau in patients with the CI 422 device.*
Conclusion: *Our results reveal that the spread of excitation and recovery functions show differences across types of implant that must be taken into account when correlations on the objective and psychoacoustic measurements are made in adults and children.*

IMAGING BILATERAL DEVELOPMENTAL PLASTICITY: EVIDENCE FROM CHILDREN WITH BILATERAL COCHLEAR IMPLANTS, BIMODAL DEVICES, AND NORMAL HEARING

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Reorganization along the bilateral auditory pathways occurs with bilateral and unilateral deprivation, often compromising efforts to promote development through use of auditory prostheses. We use auditory evoked electrophysiology/encephalography (EEG) to assess intramodal plasticity with an aim to discover both adaptive and maladaptive changes in the auditory system. Although spatial resolution of EEG is poorer than other imaging techniques, it has several advantages. EEG is non-invasive, cost effective, and appropriate for repeated use in children. Moreover, it is compatible with cochlear implant stimulation and measures both transient and sustained activity with high temporal resolution. Recent EEG results indicate that normal specialization of auditory cortices occurs over at least the first decade of life and is disrupted by asymmetric hearing. Persistent effects of unilateral cochlear implant use, resulting in a strengthening of pathways from the stimulated ear, were established within 2 years. Similar changes over the same time period were found in children with asymmetric hearing loss who used hearing aids. In addition, abnormal increases in non-auditory areas suggests unique listening strategies in children with hearing loss.

ELECTRICALLY EVOKED AUDITORY STEADY-STATE RESPONSES TO MULTIPLE SEQUENTIAL ELECTRODE STIMULATION IN COCHLEAR IMPLANT USERS

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Introduction: *Electrically evoked auditory steady-state responses (EASSRs) are electrophysiological responses phase-locked to a periodically temporal structure of the stimulus. EASSRs can be used to assess pulse rate dependent threshold levels of cochlear implant (CI) users (1). Previous EASSR studies mainly used single electrode stimulation. In normal hearing subjects, however, carrier-frequency dependent hearing thresholds can be determine defficiently with multiple auditory steady-state responses (MASSRs), by modulating each carrier with a different modulation frequency (2). The electrical analogue of MASSRs, multiple EASSRs, could potentially be used to efficiently determine the CI electrode specific threshold levels. Currently, it isunclear if multiple EASSRs can be obtained free from stimulation artifacts, and howEASSRs are affected by across electrode interactions.*
Objective: *To study the feasibility ofrecording EASSRs elicited simultaneously from multiple CI electrodes in CI subjects, and to gain insight in the effect of stimulation artifacts and electrode interactions on the measured responses.*
Materials & methods: *EASSRs were recorded from two adult Nucleus® CI users, with a 64-channel EEG setup. Monopolar stimulation (MPI +2) was used. One, two, and four CI electrodes were stimulated sequentially with a modulated pulse train of 500 pulses-per-second. For multiple electrode stimulation the inter-electrode pulse difference was set to 100 μs. Each electrode dependent pulse train was modulated with a unique modulation frequency within the 30-50 Hz range, and presented at comfort level.*
Results and conclusion: *The effect of stimulation artifacts and electrode interactions on the measured EASSR will be presented and discussed at the conference.*
Acknowledgements: *This study is funded by the Research Foundation Flanders (G.0662.13) and by the Flemish Agency for Innovation by Science and Technology (IWT110722, IWT141243, IWT150432).*
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ACROSS-CHANNEL VARIABILITY ASSESSED WITH ELECTRICALLY EVOKED AUDITORY STEADY-STATE RESPONSES IN ADULT COCHLEAR IMPLANT USERS

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Introduction: *Cochlear implant (CI) users have relatively good speech intelligibility in quiet environments. With increasing background noise, however, their performance deteriorates. In addition, and in contrast to speech-in-quiet, there is a large variability in performance across subjects. This variation in performance is related to, apart from possible confounding cognitive factors, the electrode-neuron-interface across channels. To gain insight the electrode-neuron-interface using behavioral measures, at all stimulation channels, istime consuming and requires the undisturbed attentionof the CI user. We hypothesize that electrically evoked auditory steady-state responses (EASSRs), i.e. electrophysiological responses phase-locked to the modulation of a periodical stimulus, could potentially be used, given the good relation between behavioral modulation detection thresholds and the EASSR (1), to gain insight in the variability of the electrode-neural-interface across stimulation channels.*
Objective: *To study the EASSR variability across stimulation channels for monopolar stimulation.*
Materials & methods: *EASSRs were recorded in four adult Nucleus® CI users using a 64-channel EEG setup. Monopolar stimulation was used. A 500 pulses-per-second pulse train, modulated at 40 Hz, and presented at comfort level was used to study the across-channel variability with EASSRs. Across-channel EASSRs were compared with the channel specific, behaviorally assessed threshold levels, comfort levels, and loudness growth functions.*

Results and Conclusion: *Initial results show subject dependent across-channel EASSR variations which are not directly reflected in the across-channel patterns assessed of one of the behavioral metrics. Results of in-depth analysis of the comparison between the behavioral metrics and the EASSRs will be presented at the conference.*

Acknowledgements: *R. G. and R. L. contributed equally to this work. This study is funded by the Research Foundation Flanders (G.0662.13) and by the Flemish Agency for Innovation by Science and Technology (IWT110722, IWT150432, IWT141243). The work leading to this deliverable and the results described therein has received funding from the People Programme (Marie Curie Actions) of the European Unions Seventh Framework Programme FP7/2007-2013/ under REA grant agreement PITN-GA-2012-317521.*

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FIRST EXPERIENCE WITH THE COCHLEAR CI532 SLIM MODIOLAR ELECTRODE ARRAY AND COMPARISON TO THE CONTOUR ADVANCE IN TERMS OF ELECTRODE PLACEMENT, OBJECTIVE MEASURES AND PROGRAMMING LEVELS

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Introduction: *In December 2015 Oslo University Hospital has attended the „First Experience Program" of Cochlear new Slim Modiolar electrode array. At the time of abstract submission 13 patients have been implanted with the new electrode array at our hospital. Differences in Evoked Compound action Potential (ECAP) and programming levels could be seen compare to the Contour Advance electrode.*

Objective: *Aim of this study is to investigate the differences between the Slim Modiolar electrode and the Contour Advance electrode in adult patients in terms of Objective measures such as ECAP, placement and programming levels such as C- and T-levels.*

Patients: *So far 13 adults have received a Cochlear CI532 implant at our hospital. These patients were compared with 53 adults who received a Cochlear Contour Advanceelectrode.*

Methods: *Intra-operative imaging, ECAP measurements and post OP programming levels were compared between the CI532 implant and the Contour Advance electrode.*

Results: *Preliminary data has shown that the initial programming levels are within the same range. In some patients an unusual profile was observed in the C- and T-levels and ECAP. Analysis of the fluoroscopic imaging indicated differences in modiolar proximity in the mid to basal range of the cochlear which may be the reason for different nerve responses and programming levels compared to the typical Contour electrode.*

Conclusion: *Due to the positive experience we have collected with the new CI532 implant are convinced this electrode will replace most of our Contour and CI522 implants. Just in cases of malformations of the inner ear and middle ear we may continue to use the Contour electrode array. We would suggest doing an X-ray image after each CI532 insertion.*

OPTIMIZING ELECTRODE ARRAY POSITION OF THE COCHLEAR CI532 SLIM MODIOLAR ELECTRODE ARRAY WITH PER-OPERATIVE FLUOROSCOPY AND EVOKED COMPOUND ACTION POTENTIALS

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Introduction: *In December 2015 Oslo University Hospital has attended the „First Experience Program" of Cochlear new Slim Modiolar electrode array. At the time of abstract submission 13 patients have been implanted with the new electrode array at our hospital.During the first clinical cases of the electrode array we observed an effect of the proximity of the electrode on the Evoked Compound Action Potentials (ECAP). These observations encouraged us to investigate the electrode placement more closely by testing the response to different electrode positions within the cochlea.*

Objective: *Aim of this study is to investigate if different electrode positions give a different ECAP response and threshold and if this placement difference can be observed by per-operative imaging.*

Patients: *For this study we investigated 13 patients where we had a closer investigation at three patients with various electrode positions.*

Methods: *During insertion of the CI532 electrode array per-operative fluoroscopy video was conducted to observe the insertion dynamics. The electrode array was fixed in the position of marker I, conditioning was carried out on all electrodes, then ECAP threshold and a ECAP sweep at 220CL measurements were carried out on selected electrodes in apical, mid and basal region, then the electrode array was moved further in to marker III (which moved a portion of the electrode away from the modiolus) and ECAP measurements were carried out again. Finally, the electrode array was pulled back to marker position II, (which brought the electrode back to a close modiolar proximity) and ECAP measurements were repeated. For each marker position still fluoroscopy images were taken to compare the different electrode array positions and the influence on the Objective measures.*

Results: *The 3 different marker positions did show a difference in placement visible by analysing the fluoroscopy image and by measuring the ECAP thresholds. Marker position III gave good responses in the basal area, but much higher ECAP thresholds in the mid-frequency range. There was not a large difference between Marker I and Marker II in terms of measurements. Observation of the fluoroscopy indicated marker position II after pulling back from position III gave a better placement than position III.*

Conclusion: *We conclude from our investigation that inserting to marker position III and then pulling back to marker position II will be our standard approach. Future studies will investigate which marker position is best to be used in patients with residual hearing.*

MYOGRAPHIC RECORDINGS OF THE ELECTRICALLY AND ACOUSTICALLY ELICITED STAPEDIAL REFLEX WITH A CHRONICALLY IMPLANTED RECORDING ELECTRODE

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The electrically elicited stapedial reflex threshold (ESRT) correlates very well with the maximum comfortable level (C- or M-Level) and thus, is a viable tool with which to set upper stimulation limits when fitting cochlear implant (CI) recipients. Postoperative evaluation of the muscle response using an impedance bridge is very time consuming and in many cases not possible due to middle ear disturbances of the contralateral ear. The aim of this study was to investigate the feasibility of making myographic recordings via a chronically implanted intramuscular micro needle electrode in guinea pigs.

Different recording electrodes were developed to suit the anatomical requirements and to easily penetrate the stapedial muscle. The ideal electrodes were prepared from a silicone coated Pt/Ir-wire which was uninsulated for 1 mm and sharpened at the tip to 5 µm. The reflex was elicited intraoperatively by either, contra-lateral acoustic stimulation, or by an ipsilateral dual biphasic pulse from a cochlear implant electrode. The recording electrode was left in place for 3 months. After 3 months the measurements were repeated and the muscle were removed for histological investigation.

Myographic recordings of the stapedial reflex could be obtained in the monopolar and bipolar setup intraoperatively as well as after 3 months of chronic implantation. No migration of the electrode or macroscopic damages of the muscle were observed. Microscopic changes could be detected mainly at the insertion site.

The present study demonstrate that myographic signals can be reliably recorded via a chronically implanted electrode placed into the stapedial muscle.

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EPIDURAL RECORDINGS IN COCHLEAR IMPLANT USERS

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Introduction: *On the long term it is desirable for cochlear implant (CI) users to control their device using brain signals (brain-computer-interface, BCI). Therefore it is mandatory to use implanted electrodes for recording these signals.*

Method: *In this project we study the possibilities of recording neuronal signals via epidural electrodes in CI users. For this purpose three epidural electrodes are implanted temporarily within the CI surgery. With these electrodes AEP recordings are performed and compared to standard clinical electrodes settings. Within the surgery electrically evoked Auditory Brainstem Responses (eABR) are recorded. In the days after the surgery eABR, Middle Latency Responses (MLR), Cortically Evoked Response Audiometry (CERA), Mismatch Negativity (MMN) and P300 are recorded stimulating the CI. After some days the epidural electrodes are removed.*

Results: *Up to now the first data sets are obtained with two patients showing promising results. In principal this approach could be shown to be feasible. The epidural electrodes could be placed and fixed such that they didn't move, and after some days they could be removed safely and without pain for the patient. With the epidural electrodes the eABR could be recorded with less stimulation artefacts than with surface electrodes. Also the CI stimulated CERA yielded clear results.*

Conclusion: *Altogether the approach is feasible, safe and well tolerated by the patients. First epidural recordings show promising results with clear evoked potentials. Thus, more data can be obtained and further steps towards the use of brain signals for device control can be performed.*

EXTRA- AND INTRACOCHLEAR ELECTROPHYSIOLOGICAL RECORDINGS DURING COCHLEAR IMPLANTATION

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Introduction: *To preserve residual hearing during cochlear implant (CI) surgery it is desirable to use intraoperative monitoring during the electrode insertion. A promising method is the recording of cochlear microphonics (CM). The aim of the monitoring is to identify critical steps as well to modify the ongoing insertion procedure immediately if necessary.*

Method: *Within the project, CMs were recorded intraoperatively in patients with significant residual hearing. The recording took place at different insertion depths. CMs were recorded in 9 patients receiving a Med-El Synchrony implant with different FLEX electrodes. The recording cotton wick electrode was placed on the promontory wall. Currently in 3 patients the "theragnostic probe" was used. This CI electrode (FLEX20, Med-El) has three additional recording contacts at the tip being used to record CMs intracochlear. The stimulation was done acoustically using tone bursts between 250 Hz and 4 kHz.*

Further, the pure tone audiograms (PTA) of the patients were analyzed preoperatively and at first fitting.

Results: *In most extracochlear recordings the amplitude of the CMs did not change during the insertion, whereas intracochlear recordings depended on insertion depth. With extracochlear recordings the according spectra showed peaks up to 0.5 uV, with intracochlear recordings up to 20 uV.*

The median hearing loss at first fitting was 20.0 dB for FLEX20 (n=4) and 21.25 dB for FLEX28 (n=8).

Conclusion: *The recording of CMs during CI insertion was feasible. Intracochlear measured amplitudes exceeded the amplitudes of extracochlear recordings majorly. In depth analysis is needed to understand the correlation between CM recordings and postoperative hearing loss.*

RECOVERY CHARACTERISTICS FOR ECAP MEASUREMENT UTILIZING SHORT PULSE INTERVALS

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Introduction: *Measurements of the refractory properties of the Electrically evoked Compound Action Potential (ECAP) of the auditory nerve in Cochlear Implant (CI) users at Masker Probe Intervals (MPIs) below 300µs are influenced by facilitation (=summation) and absolute refractoriness (=masking) effects (Boulet, et al, 2016).*

Objective: *In this study we aim to resolve the contributions of facilitation and absolute refractoriness to ECAPs recorded at short MPIs.*

Material and Method: *13 cochlear implant users implanted with Cochlear® Nucleus™ CI512 or CI24RE(CA) took part in the investigations. ECAPs were measured with the method described by Miller, et al. (2000). Probe Current Levels (PCLs) varied from visually detected Threshold of the ECAP (vT-ECAP) to vT-ECAP+20CL. Masker Current Levels(MCLs) varied from 0CL to vT-ECAP+50CL. MPIs varied between 13–200 µs and included a control measurement at 10 ms.*

Results: *ECAP N1P1 amplitudes showed a non-monotonic behavior with changing MCLs. ECAP amplitudes larger than those found at control level were found for MCLs below vT-ECAP. Around vT-ECAP a local maximum of the ECAP amplitude was found. ECAP amplitudes decreased towards 0 (absolute refractoriness) when MCL was increased up to vTECAP+50CL. The ECAP amplitude behavior with changing MCLs was similar for all PCLs and MPI=13…200 µs.*

Conclusion: *ECAPs recorded with MPIs within the absolute refractory period are influenced by facilitation and absolute refractoriness. Facilitation effects are most pronounced for MCL at or below vT-ECAP, while absolute refractoriness effects increase with MCL. The local maximum of the ECAP amplitude for MCLs around vT-ECAP can be explained by the mutual influence of facilitation and absolute refractoriness.*

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AMPLITUDES OF ELECTRICALLY EVOKED COMPOUND ACTION POTENTIALS IN CHILDREN AND ADULTS

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Electrically evoked compound action potentials (ECAP) provide objective information about the functional status of the auditory nerve. During the last decade a number of studies exploited the clinical applicability. Most of them focused on ECAP thresholds, i.e. the stimulation value at which a neural response is detectable. Until now, absolute ECAP amplitudes were of little interest and no comparisons to outcome data were published. However, it is reasonable to assume that ECAP amplitudes provide information about the number of auditory nerve fibers being excited by an electrical pulse. In particular, the N1-P2 interpeak amplitude may provide information about the amount of neural excitation. Therefore, it is reasonable to assume that shorter period of deprivation prior to cochlear implantation results in larger ECAP amplitudes. Our human model for short deprivation periods are children who were provided with a cochlear implant (CI) during the first years of life.

We reviewed n=367 ECAP intraoperative ECAP measurements in children under 2 years of age (n=77) and postlingually deafened adults (n=290) who were provided with a nucleus contour advanced electrode. ECAP were recorded at al 22 electrodes at a fix current level of 230 C.U.

Mean ECAP amplitudes for the children group were 448±241 µV and 261±165 µV for the adult group, respectively. Median values for the children and adult group were 409 µV and 227 µV, respectively. The difference between both groups is highly significant (<10-14).

Results show that ECAP amplitudes provide information about the functional status of the auditory nerve on an Objective level. Since both surgical technique and CI type were identical, the differences are due to different etiologies and may reflect different neural degeneration processes.

CORRELATION BETWEEN PSYCHOMETRIC DATA AND THRESHOLD OBTAINED FROM AUDITORY RESPONSE TELEMETRY

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Introduction: *Auditory response telemetry (ART) can be used to objective ly support the individual fitting of cochlear implant (CI) speech processors. However, the reliability of automatic methods used to determine the threshold of electrically evoked compound actions potentials is limited.*

Objective: *The present study aims to improve the algorithm of threshold detection in order to achieve a better coincidence with psychometric measures as e.g. THR (perception threshold for electric stimuli) or MCL (most comfortable level).*

Methods: *In 30 patients receiving MED-EL Synchrony implants, ART data were collected immediately after electrode insertion. All 12 electrodes served sequentially as stimulation and recording sites. Growth functions consisting of 20 recordings were measured in steps of 60 cu from 0 to 1140 cu. For the quantitative description of the response a parameter Q related to the signal to noise ratio was derived from each curve after eliminating the stimulus artifact. The threshold was defined by the criterion Q=6 dB. A comprehensive correlation analysis was applied to compare these thresholds with the psychometric stimulus levels THR and MCL.*

Results: *Objective thresholds are obtained in 95% of all record series. The correlation between objective measures and psychometric data is significantly higher with the new algorithm than with the conventional procedure. Moreover, the numerical ECAP threshold determined automatically coincides remarkably well with the threshold determined visually by an expert.*

Discussion: *The advantage of the new method is based on two essential features: 1st, the parameter Qis more efficient than the conventional amplitude difference; 2nd, the involvement of all curves, even those without a visible response, yields a direct image of the threshold transition.*

Conclusion: *he availability of an algorithm which yields reliable objective thresholds justifies the hope that better fittings will be possible in young children and uncooperative patients.*

ELECTROCOCHLEOGRAPHY TO MONITOR COCHLEAR FUNCTION DURING COCHLEAR IMPLANTATION

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Introduction: *The aim of this study was to assess changes in cochlear function during cochlear implantation by electrocochleography (ECoG) and to correlate such changes hearing preservation.*

Methods: *ECoG responses to tone bursts at 250, 500, 750, and 1000 Hz and to click stimuli were recorded during insertion of the cochlear implant array. CBCTs were conducted within 6 weeks after surgery. Changes of intraoperative ECoG recordings and CBCT findings were correlated with postoperative threshold shifts in pure-tone audiograms.*

Results: *Decrease of low-frequency ECoG responses at 250, 500, 750, and 1000 Hz during insertion of the electrode array was associated with no or minimal residual hearing 4 weeks after surgery. Decrease of ECoG responses to click stimuli occurred without detectable changes of low-frequency ECoG responses. Such isolated changes in high-frequency ECoG responses were associated with a mean hearing loss of 21 dB in postoperative pure-tone audiograms. Scalar dislocation correlated with a decrease of low-frequency ECoG responses and a complete loss of residual hearing.*
Conclusion: *Hearing loss of ≤11 dB is not associated with detectable decrease in intraoperative ECoG recordings. However, a majority of cases with threshold shifts of >11 dB or complete hearing loss showed a decrease of either high- or low-frequency ECoG responses. This suggests that acute cochlear trauma during cochlear implantation is an important predictor for postoperative hearing loss although in some cases postoperative mechanisms independent from surgical trauma seem play a role.*

OBJECTIVE FUNCTIONAL PERI-IMPLANT VASCULAR ANALYSIS IN BAHA IMPLANTEES

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Objectives: *The objective of this study was to evaluate the impact of hydroxyapatite coating of newly designed osseointegrated fixtures' abutments on the postoperative complication rates.*
Study design: *The integrity of peri-implant microcirculation was used as a marker to compare tissue viability after different surgical techniques. Laser-Doppler Flowmetry (LDF) measures alone, and coupled with heat provocation tests were applied to test the different microcircular patterns.*
Study cochorts: *Measures for 17 consecutively implanted patients (8 women, 9 men, ages ranged from 18 to 77 years) were recruited; seven with soft tissue reduction (STR); and 10 with soft tissue preservation (STP). Thirteen non-operated retroauricular areas were examined as naive controls.*
Results: *In isotherm conditions the baseline blood flow remained stable in all groups. The naive control patients demonstrated significant changes of blood flux in the intact skin. The nonimplanted yet previously operated contralateral sides of the patients demonstrated marginally lower ($p = 0.09$) blood flux index. The STR sides however, showed significantly lower (average 217 %) provoked blood flux compared to controls ($p<0.001$). At the STP sides a maladaptation could be observed (average 316 %) compared to the contralateral sides ($p = 0.53$). STP sides demonstrated a significantly better blood flow improvement compared to the STR sides ($p=0.02$).*
Discussion: *These results suggest a favorable postoperative condition of vascular microcirculation after STP, than after STR surgery. The possibly faster wound healing and lower potential complication rate may widen the inclusion criteria and maybe beneficial for the patient compliance with a better quality-of-life.*

OBJECTIVE VESTIBULAR ASSESSMENT FOLLOWING COCHLEAR IMPLANTATION

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Objectives: *The objective of this study was to evaluate the impact of coclear implantation on the postoperative peripheral vestibular complication rates. Cochlear implantation (CI) inherently carries the potential risk for periferal vestibular system insult*
Study design: *The vestibulo-ocular reflex function analysis (HIMP and SHIMP paradigms) and the vestibular-evoked myogenic potential (VEMP) tests were introduced into the objective diagnostic pool as further supplements to the classic subjective evaluation. The Dizziness Handicap Inventory (DHI) waas alo completed.*
Study cochorts: *30 ears (15 ipsilaterally implanted and 15 contralaterally non-implanted) ears were subjectively and objectively analyzed minimum 6 months following CI.*
Conclusions: *Although small and negligible rate of labyrinthine injury was observed, being comparable to that for other risks of CI it is important to inform CI candidates about possible risk to balance function.*

ELECTRICALLY-EVOKED COMPOUND ACTION POTENTIALS RECORDED INTRA- OR POST-OPERATIVELY IN ADULT COCHLEAR IMPLANT USERS: CORRELATIONS WITH DEMOGRAPHICS, PERFORMANCES AND ESTIMATION OF MOST COMFORTABLE LEVEL

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Introduction: *Electrically-evoked compound action potentials (ECAP) remain the easiest and quickest objective measures to assess cochlear implant (CI) efficiency.*
Objective: *To investigate: 1) differences of ECAP recorded intra- or post-operatively between different cochlear regions, 2) correlations with demographic data and fitting parameters, 3) relationship between subjective Most Comfort Level (MCL), ECAP characteristics and demographic data.*
Material and Methods: *ECAP measurements were obtained using Med-El Maestro Software for three electrode locations (basal, medial, apical) in*
1) 18 adults during surgery ("IO" group) and
2) 28 experienced adult CI users (more than 11 months of CI experience).
Determination of ECAP threshold, maximal amplitude, latency and Amplitude Growth Function (AGF) slope; recording of electrodes' impedances and MCL was done during the first and second fitting (8 days later) in the "IO" group. Pure-tone and speech audiometry tests were performed during this second fitting.
For the "experienced group", these data were recorded during a unique session.
Results: *Significant positive correlations were found between ECAP thresholds and MCL in the "experienced group" for all locations and for apical and basal regions during the second fitting of the "IO" group. 40% and 10% of the MCL's observed variances were explained by demographic data and AGF parameters in the "experienced" and the "IO" group respectively. No significant difference was seen between ECAP parameters of the different cochlear regions.*
Conclusion: *Preliminary results confirm that ECAP alone is not sufficient to accurately estimate the MCL in CI recipients but represent an interesting tool for elaborating more complex predictive models.*

COACHING WITH DATA LOGGING: AN EMPOWERING APPROACH TO CLINICAL CONVERSATIONS WITH RECIPIENTS AND PARENTS USING HEARING IMPLANT DATA LOGGING

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In order to help recipients of any hearing implant (i.e. Cochlear Implant, Baha etc.) to achieve their optimal outcomes, clinicians may wish to discuss changes that the recipient or parents may need to make; motivating people to make changes to how they behave can be a challenge. Data logging with Cochlear's N6 and Baha 5 sound processors allows useful information to be stored, for example, about device use and the listening environment etc. This paper will present one way to use this information to support, guide and empower recipients or in the case of a child, their parents; a coaching approach to conversations with recipients or parents about their individual data logs can help to motivate and empower them to set their own goals and to make the changes they want. By sharing information in a clear and understandable way, asking questions and reflecting on the answers given, both clinician and client can work together to discover the best way forward; using a coaching approach can further improve the effectiveness of the device and make it easier to gain optimal benefit for a particular individual by providing a foundation for supportive, transparent and collaborative discussions. The key elements of a coaching approach, how this has been applied in clinical practice using the information from data logging with the Cochlear N6 and Baha 5 sound processors as well as clinical examples and outcomes will be addressed.

EARLY HEARING LOSS DIAGNOSIS BASED ON CONSANGUINEOUS MARRIAGES AND METHODS OF REHABILITATION OF PATIENTS

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Introduction: *The condition and quality of family influences on the health of society. According to the Ministry of Health and Social Protection of the Population of the*

Republic of Tajikistan there 26043 disabled children under the age of 18 years, according to experts 35% of the children born in consanguineous marriages.
Objective: *Early diagnosis and treatment of sensorineural hearing loss based on closely related marriages of children.*
Materials: *At the ENT Clinic of the National Medical Center of the RT were examined 52 child with hearing loss and speech disorders based on closely related parents' marriage, aged from 3 to 12 years. Testing consisted of tonal threshold audiometry with Methods of estimation of air and bone conduction, otoacoustic emission and registration of ABR.*
Results: *Audiology studies have shown that in 36 (69.2%) children had varying degrees of sensorineural hearing loss with a secondary speech underdevelopment. 6 children have been diagnosed with sensorineural hearing loss I level, 8 children sensorineural hearing loss II degree, have 10 children sensorineural hearing loss III, and 12 children have sensorineural hearing loss IV degree or practical deafness. In analyzing the developed of deafness at surveyed children was due to closely related parents' marriage. After complex treatment of neuritis ear prosthesis in children with IV degree of hearing loss were recommended operation – cochlear implantation.*
Conclusion: *The use of these subjective and objective audiological research methods allows the timely and accurate set of genetic hearing loss in children and carry out the necessary rehabilitation measures.*

PREDICTING THE DEGREE OF DIFFICULTY IN COCHLEAR IMPLANT SURGERY – THE USE OF AN OBJECTIVE LY STRUCTURED IMAGING BASED GRADING SYSTEM

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Introduction: *Hearing preservation and lowering the age for cochlear implant (CI) surgery has resulted in increased emphasis on improving surgical technique. Variations in the anatomy of the temporal bone and in cochlear orientation can often cause an intraoperative challenge to the surgeon.*
Objective: *The aim of this study was to assess if the use of an objective ly structured grading system based on High Resolution Computer Tomography (HRCT) and Magnetic Resonance Imaging (MRI) correlated with intraoperative findings and helped the surgeon predict the degree of difficulty in cochlear implant (CI) surgery in our practice.*
Methods: *The senior author is the primary CI surgeon at the institution with a cohort of over 700 cochlear implant recipients. Both HRCT and MRI are routinely used in the preoperative evaluation of all patients undergoing CI surgery. A 10 point imaging based grading system described by Vaid et al. [IJOHNS 2015; 67 (2): 150-158.] was used consecutively in 70 patients to score the findings (documented by the second author) and predict potential difficulties. This score was compared to the intraoperative findings and the duration of CI surgery (documented by the first author).*
Results: *The findings on imaging and the resultant score seemed to correlate with intraoperative findings. The surgeon was able to predict the potential difficulties encountered. Longer surgical times were seen in patients with a higher score on imaging. The details of the scoring system and findings will be discussed.*
Conclusion: *The use of a structured imaging based grading system can help a CI surgeon anticipate the challenges that might be encountered during surgery and thus predict intraoperative issues and surgical time, and is particularly useful for the novice CI surgeons.*

COMPARISON OF BAHA SOUND PROCESSORS WITH CORTICAL EVOKED RESPONSES

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Introduction: *as in every implantable hearing assistive modalities, one of key factors of the performance gained with the bone anchored hearing aid systems (Baha) is the sound processor (SP). Patients fitted with the third generation Baha SPs (BP100, BP110) achieved outstanding quality of life improvement; however various possible difficulties aroused during the wearing and the programming (i.e. feedback, resonance, etc.). During the last years Baha 4 SP also became available in Hungary.*
Objectives: *The aim of our study was to compare the achieved results with the Baha 4 and the predecessor SP.*
Materials & methods: *Fifteen Baha implantees were recruited into our study, who were fitted with BP100 or BP110 SPs. First the Baha 4 SP was programmed then following a short adaptation period comparative subjective (sound field pure tone and speech sudiometry) and objective (cortical evoked responses) measurements were performed.*
Results: *Our results showed significantly better pure tone thresholds and speech intelligibility values when Baha 4 SP was fitted in the group of implantees supplied with Baha Attract system. The amplitudes of cortical responses also proved to be significantly higher, tested through the Baha 4, compared to the results gained with BP100 and BP110 SPs.*
Conclusion: *Based on our results the Baha 4 SP provides significantly better auditive capabilities compared to the 3rd generation SPs.*

AN OBJECTIVE ESTIMATION OF AIR-BONE-GAP IN COCHLEAR IMPLANT RECIPIENTS WITH RESIDUAL HEARING USING ELECTROCOCHLEOGRAPHY

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Background: *Residual hearing in the implanted ear is mostly assed by measuring air-conduction (AC) thresholds and very rarely by bone-conduction (BC) thresholds. The difference between AC and BC thresholds is known as air-bone-gap (ABG). Some patients show increase in ABG following cochlear implantation which may be attributed to changes in middle and/or inner ear mechanics and/or cochlear fluid dynamics due to the presence of implant array in the scala tympani. In addition, in low ferquencies and high level of stimulation bone oscillator may produce vibrotactile sensation which may be interpreted as a behavioral response and contribute to the increase in ABG. Also, BC behavioral responses can be influenced by presence hearing in contralateral ear. Therefore, one needs an objective method to measure AC and BC thresholds in patients with residual hearing in the implanted ear.*
Hypothesis: *Electrocochleography (ECoG) waveforms measured using AC and BC stimulation can provide an objective method to asses ABG in patients with residual hearing in the implanted ear.*
Objective: *Are two folds*
1) to measure ECoG waveforms for AC and BC stimulation in cochlear implant recipients with residual hearing
2) to rule out the presence of stimulus artifact in ECoG waveforms recorded using implant electronics.
Methods: *We developed a technique to post-operatively measure ECoG potentials using Advanced Bionics CI intra-cochlear electrodes. Specifically, acoustic stimulus presentation was synchronized with intra-cochlear recording, and acoustic ECoG potentials were measured. AC and BC ECoG waveforms were recorded using insert earphones and B-71 bone oscillator in implant recipients with residual hearing. Additionally, BC ECoG waveforms were measured with an occluded ear canal to rule out the presence of vibrotactile artifacts during ECOG measurements.*
Results: *ECOG responses measured for AC and BC stimuli correlated well with those measured with behavioral pure tone audiometry. Larger BC ECOG potentials were measured when the ear canal was occluded with an ear plug which indicates that increase in BC stimulation produced a corresponding increase in the physiological response due to occlusion effect which was measured using ECOG.*
Conclusion: *AC and BC ECOG measurement provided as an objective method to measure to asses ABG in patients with residual hearing in the implanted ear.*

ELECTROCOCHLEOGRAPHY USING HIRES90K® COCHLEAR IMPLANT – A TOOL FOR OBJECTIVE ESTIMATION OF ELECTRO-ACOUSTIC INTERACTIONS

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Advanced Bionics Corporation

Objective: *To develop an objective technique for measuring interactions between electric and acoustic components in a combined electro-acoustic stimulation (EAS).*
Background: *The increased incidence of acoustic hearing in CI candidates has necessitated the need for combined electric and acoustic stimulation to the cochlea. Insights into interactions between the two stimulation modes may allow one to optimize the combined system. Electrocochleographic (ECoG) potentials measured through CIs may provide an objective technique for evaluating such interactions.*
Methods: *We developed a technique to post-operatively measure ECoG potentials using Advanced Bionics CI intra-cochlear electrodes. Specifically, acoustic stimulus presentation was synchronized with intra-cochlear recording, and acoustic ECoG potentials were measured and compared between acoustic alone and acoustic in presence of electrical stimuli. This technique was verified with different stimulus rates similar to clinical stimulation rates.*
Results: *Current method successfully measured acoustic ECoG responses in presence of the electrical stimulus. The current technique is able to cancel the electrical stimulus artifacts up to stimulus rates of 1200 Hz. Response amplitudes to acoustic stimuli were significantly altered by presence of electrical stimulation. The degree of interaction varied by acoustic frequency, and electrode location of electrical stimulation.*

Conclusion: *The new technique may provide an objective method for estimating electro-acoustic interactions and optimize EAS benefits.*

USE OF AIDED CORTICAL ASSESSMENT TO TRACK AUDITORY MATURATION OF OBJECTIVELY PROGRAMMED, PAEDIATRIC, COCHLEAR IMPLANT USERS

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Introduction: *With adequate access to sound PI latencies of cochlear implanted (CI) children shorten overtime. Collective cortical response data of optimally fit CI users can provide guidelines on when and what type of cortical responses to expect.*
Objective: *To compare cortical responses of paediatric CI users, programmed using the objective electrically elicited stapedial reflex threshold (eSRT) fitting method, with normal hearing (NH) children in terms of aided cortical assessment (ACA) score and determine 'expected' ACA scores over first six months of CI use.*
Method: *Cortical auditory evoked potentials (CAEPs) were recorded, in response to speech tokens /m/, /g/ and /t/ at 55 dB SPL in the free field, repeatedly, for 45 CI users and once for 20 NH children, all aged under 4 years. Cortical responses were scored according to presence of PI and latency. Mean ACA scores of CI users were compared over time and against NH children's scores.*
Results: *The mean ACA score was 6 for NH children and 4±1.781 for CI users. ACA scores for CI users improved over time, particularly during the first 3 months but were adversely affected by a significantly lower PI response rate to /m/ at all test intervals. Response rate to /g/ and /t/ was not significantly different from that of NH children with 3 months of device use.*
Conclusion: *CI users with eSRT based programs have cortical responses similar to NH children's within 3-6 months. Less than optimum cortical responses may prompt timely solutions.*

USE OF ELECTRICALLY ELICITED AUDITORY BRAINSTEM RESPONSES, ELECTRICALLY ELICITED STAPEDIAL REFLEX THRESHOLDS AND AIDED CORTICAL ASSESSMENT IN PROGRAMMING OF 2 PAEDIATRIC AUDITORY BRAINSTEM IMPLANT USERS

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Introduction: *Paediatric auditory brainstem (ABI) programming is challenging. objective measures may provide information for programming.*
Objective: *To evaluate effectiveness of electrically elicited auditory brain stem responses (eABR); electrically elicited stapedial reflex thresholds (eSRT) and aided cortical assessment (ACA) for ABI programming.*
Method: *2 children aged 2.8 (A) and 6.4 (B) years received an ABI. eABR thresholds were established at initial stimulation under general anesthetic in the operating room. At behavioral switch on MCL's were set at qu levels where ABI users had reliable responses. At subsequent fits thresholds were measured and MCL set at eSRT level. Programs were validated using ACA and sound field thresholds across 0.25-6 kHz. eABR thresholds were compared with eSRT set MCL's.*
Results: *eSRT's were recorded on 8 and 11 electrodes for child A and B, respectively. PI responses to low, mid and high frequency speech stimuli, presented at 55 dB SPL, were recorded for child A and B. PI latencies shortened overtime for child B. Sound field thresholds ranged from 35-55 dB HL in both users. eABR thresholds differed from eSRT set MCL by –13 to 106 qu and –18 to + 18 qu for child A and B , respectively. Some electrodes with eABR thresholds were not activated and some with no response were activated. The eABR profile did not follow the MCL profile.*
Conclusion: *Measuring eSRT allows accurate setting of MCL. PI responses at 55 dB SPL validates access to soft sound. For these ABI users eABR THR information did not provide useful programming information.*

BENEFITS OF UNILATERAL COCHLEAR IMPLANTATION ON QUALITY OF LIFE OF CHILDREN AND ADULTS

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Objective: *The purpose of this study was to compare communicative performance of children and adults before and after unilateral cochlear implantation.*
Materials and methods: *123 deaf adults and children who received a cochlear implant were surveyed using the Sanders Profile Questionnaires preoperatively and at least 2 years postoperatively. The subjects were divided in four groups: adults, children, children with additional disabilities, and prelinqually deaf adults who underwent surgery later in life. In the case of the children the Questionnaires were answered by the subjects' parents and teachers.*
Results: *Findings demonstrated clinically relevant benefits in communicative performance with differences pre to post implantation being significant in all Sanders Scales for all the four categories of subjects.*
Conclusion: *All categories of subjects demonstrated enhanced auditory and communicative performance and experienced improved Quality of Life after at least 2 years of successful unilateral cochlear implantation.*

SPEECH PERFORMANCE OF GREEK CHILDREN WITH INTELLECTUAL DISABILITY AFTER SUCCESSFUL COCHLEAR IMPLANTATION

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Objective: *The purpose of this study was to investigate the performance of children with intellectual disability after cochlear implantation.*
Materials and methods: *Twenty implanted children with intellectual disability were included. Progress in speech detection, recognition and comprehension were measured using free field pure tone audiometry and speech audiometry recognition and comprehension tests in Greek language before and after implantation. We retrospectively examined outcomes and explored the association between the progress made and the level of intellectual disability after implantation.*
Results: *Speech perception and speech intelligibility of children with mild intellectual disability improved after implantation while free field audiometry test scores did not differ significantly between children with mild intellectual disability and children with no additional disabilities. However, due to the limitations in speech and language development, the results in speech discrimination test were moderate. In addition, children could communicate by means of vocalization 2 years after successful implantation.*
Conclusion: *Children with intellectual disability obtain demonstrable benefit from cochlear implantation, and their postoperative performance was influenced by the level of intellectual disability.*

COMPARING THE DEVELOPMENT OF LINGUISTIC ABILITIES BETWEEN CHILDREN USING COCHLEAR IMPLANTS WITH THOSE USING HEARING AIDS

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Introduction: *Cochlear implants and hearing aids are widely used by children with hearing loss. These children attend special schools, integrating classes or typical classes with parallel support.*
Aim: *The aim of this paper is to compare the development of linguistic abilities of children using cochlear implants with those using hearing aids.*
Materials and methods: *The sample of this paper included 140 children with profound prelingual sensory-neutral hearing loss who attend primary education at the area of Central Macedonia. These children attend typical or integrating schools. The group of children that use cochlear implants includes 68 students and the group of those that use hearing aids includes 72 students.*
The Psychometric Test of Language Acquisition Competence (L-a-T-o) was used to evaluate the three linguistic forms (semantic, syntactic and phonological) as well as the three linguistic systems of reception, organization and production of oral speech of children.
Results: *Findings revealed that children with cochlear implants exhibited enhanced performance, from 5 to 22,5%, to those with hearing aids at*
1) General Level of Oral Speech,
2) Level of Auditory Reception,
3) Level of Organizational Ability
4) Level of Expressing Ability,
5) Semantic Level,
6) Syntactic Level and
7) Phonological Level.

Conclusion: *Children with cochlear implants demonstrated a better performance than those with hearing aids, and improved linguistic abilities that are being activated during the organizing process in the language acquisition and the speech and language development as well.*

A SIMPLE STETHOSCOPE FOR COCHLEAR IMPLANTS USERS

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Introduction: *Auscultation by healthcare professionals using cochlear implants is a problem raised following the increased number of cochlear implantations. It represents a major burden in everyday medical practice and there are no publications concerning the use of stethoscopes by medical population among cochlear implant recipients.*
Aim: *We are aiming to present the first array in the literature that allows the connection of the stethoscope to the cochlear implant system.*
Materials and Methods: *We present a simple stethoscope which is connected to the cochlear implant system through the sound processor and two cases where this has been successfully applied. The lapel microphone was inserted in the distal part of a compatible stethoscope's tube. Monitoring headphones were connected to the implant in order to assess the findings.*
Conclusion: *Both volunteers were satisfied by the quality of auscultation and an external observer confirmed the accuracy of the examination. Auscultation demands not only hardware connection between the stethoscope and the sound processor of the implant but also remapping in order to adjust the hearing thresholds to the target frequency range.*

PILOT STUDY WITH A NEW ELECTRODE VOLTAGE TELEMETRY TOOL FOR THE NUCLEUS COCHLEAR IMPLANT

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Introduction: *A new Electrode Voltage Telemetry tool, called EVT, was developed to improve on the capabilities of the CS19 Intra-Cochlear Voltage-Matrix (IVM) test for the Nucleus cochlear implant. EVT measures the electric field spread along the electrode array of a cochlear implant with respect to an extra-cochlear electrode, resulting from monopolar stimulation of each electrode individually. Normalized with respect to stimulation current, these voltages are represented in an impedance matrix. EVT measures the impedance matrix at 10 samples distributed over the 2 phases of the 56-μs biphasic pulse and allows for higher stimulation levels than IVM.*
Objective: *The study aims a technical validation of the new EVT tool in a clinical environment, evaluating its accuracy at the loudest stimulation levels acceptable for the patient (LAPL).*
Methods: *EVT recordings at LAPL and at two lower current levels were compared to impedance measurements with Custom Sound and to the CS-19 IVM test for 5 subjects.*
Results: *EVT measurements showed consistency with CS-19 IVM and Custom Sound data. LAPL for EVT was comparable to the maximum C-level from the subject's programming MAP. Increasing the stimulation current resulted in an improved capability of resolving transimpedances for recording electrodes far away from the stimulation electrode.*
Conclusion: *The viable speed, simplicity and improved resolving power of the new EVT tool encourage studies towards understanding of the relation between the electric field spread on the one hand, and speech understanding, electrode placement, electrode discrimination, and cochlear tissue growth on the other hand.*

ELECTRODE ARRAY TIP FOLD OVER DETECTION BY INTRAOPERATIVE SPREAD OF EXCITATION MEASUREMENTS

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Background: *After cochlear implant insertion intraoperative integrity testsare common practice in most clinics, including impedance measurements and measurement of thresholds for electrically evoked compound action potentials (ECAP). However, this data does not provide any cue on an accurate electrode array placement. Spread of excitation (SOE) measurements on the other side might be used as an indicator for electrode tip foldover. The objective verification of a proper electrode positioning without additional x-ray imaging is anticipated, since upcoming electrodes require a different insertion approach.*
Objective: *The main goal of this study was to evaluate intraoperatively SOE in order to detect a potential tip foldover.*
Methods: *In 77implanted ears (CI24RE(CA), CI512 and CI532; Cochlear Ltd.) SOE and NRT thresholds were recorded intraoperatively. Probe electrode (#15) was stimulated with 210 current levels (cl). Data was evaluated regarding the N1-P1 amplitude, SOE width and NRT in relation to five tip foldover cases approved by x-ray imaging.*
Results: *To obtaind escriptive SOE data probe stimulation level must be set at least 20 CL above NRT. In all tip foldover cases there are N1-P1 amplitudes at the most apical electrode. In comparison with ECAP threshold SOE data allow to identify the tip foldover cases.*
Conclusion: *SOE measures provide a useful tool of objectifying the array position within the cochlear intraoperatively. However, intraoperative imaging is still inevitable.*

ELECTRICALLY EVOKED POTENTIALS OF THE APICAL AND MEDIAL REGION OF THE COCHLEA IN CHILDREN IMPLANTED WITH DEEP INSERTION ELECTRODES

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Introduction: *The literature has been shown that the amplitude of the electrically evoked compound action potential at the apical region is increased, suggesting higher neural density in that region. May the latency of the wave V of the electrical auditory brainstem response (eABR) offer the same information?*
Objective: *To evaluate whether the latency of the eABR wave V at the apical is different from the medial electrodes in deep cochlear implantation.*
Methods: *This project was approved by the Ethics Committee of the Institution under protocol number 720.393. Selection criteria included children under 4 years of age, with bilateral severe to profound sensorineural hearing loss, complete insertion of the Medel Flex28 electrode array, confirmed by the post-operative transorbitary radiography. Children with etiologies involving neonatal events, inner ear malformations, nerve abnormalities, developmental delays or autistic spectrum disorder were excluded. Seven children were selected and were submitted to eABR intraoperatively and after 6 months of use CI use. The latency of wave V was analysed at apical electrodes (e1 and e2), and at a medial region electrode (e6).*
Results: *Recordings could reveal the presence of wave V at both the intraoperative and the postoperative times, while the absences were due to artefacts. Wave V latenciesat both times were respectively: e1: 4.18 (±0.34), 3.82 (±0.45) (p=0.08); e2: 3.79 (±0.31), 3.81(±0.72) (p=0.10); e6: 3.88 (±0.42), 3.83 (±0.42) (p=0.48), with no statistical significance.*
Conclusion: *There were no differences in the latency of the eABR wave V at the apical or the medial electrodes in deep cochlear implantation.*

CAN SQUARE-WAVE MODULATED HIGH-RATE PULSE TRAINS BE USED TO PREDICT COCHLEAR IMPLANT THRESHOLDS USING EABR?

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While eCAP and eABR thresholds for low-rate pulse trains show strong correlations with behavioral thresholds measured at the same rate, the correlations with thresholds measured at higher rates, such as used clinically, are much weaker. This may be due to the fact that the auditory nerve response to high-rate stimuli is influenced by several temporal processes acting on a short time scale and not influential at low rates. Here, we investigate if high-rate pulse trains modulated by a low-frequency square wave may reflect these processes and be used to better predict the threshold of single-electrode pulse trains used clinically.
Behavioral detection thresholds were measured for 500-ms stimuli with a repetition period of 31 Hz in nine Med-EL users. The stimuli differed in the number of pulses

present in each period (from 1 to 32), the inter-pulse interval (IPI) within each period (0 or 1 ms) and the electrode location (apical or basal). For 32 pulses and an IPI of 1 ms, the stimulus was a regular 1000 pps pulse train, similar to that used clinically. We show that the correlation between behavioral thresholds obtained for this clinical pulse train and for 0-ms IPI, square-wave modulated pulse trains increased as the number of pulses within each period of the modulator increased. This indicates that square-wave modulated high-rate pulse trains may provide a better predictor of clinical thresholds than low-rate pulse trains. Preliminary measures of eABRs in response to such stimuli will be presented.

AGE-RELATED AND NOISE-INDUCED HEARING LOSS IN BHMT NULL MICE: ELECTROPHYSIOLOGICAL, HISTOLOGICAL AND GENE EXPRESSION LONGITUDINAL ANALYSIS

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Introduction: *The causes of age-related hearing loss (ARHL) are not fully understood; nutritional imbalance is emerging as a causative factor (1). Decreased levels of betainehomocysteine S-methyltransferase (BHMT) lead tohyperhomocysteinemia (Hcy), whichcorrelates with HL (2, 3). Conversely, noise-induced hearing loss (NIHL) triggers oxidative stress, inflammation and alterations in cochlear metabolism (4).Thus, nutritional modulation ofHcy metabolismcould prevent HL.*
Objective: *Tofurther understand the role of BHMT in HLand cochlear metabolism by comparative evaluation ofauditory function, cochlear cytoarchitecture and gene expression.*
Materials/patients & methods: *Auditory Brainstem Response (ABR) were registered in Bhmt knock-out (2) and wild type mice from 2 to 12 months in ARHL experiment; and before and at 2, 14 and 28 days after noise exposure in NIHL assay. Cochleae were collected to study gene expression changes in Hcy metabolism and morphological alterations as described (4, 5).*
Results and conclusion: *No statistical differences among groups were found in ABR thresholds after noise or during aging, although subtle defects in signal transmission were detected. In conclusion, despite previous work pointing to BHMT as a critical enzyme for auditory function, deletion of this gene in C57BL/6J mice does not have an obvious impact. Ongoing experiments will allow evaluation of putative compensatory effects on transcription.*

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PROMONTORY ELECTRICALLY AUDITORY BRAINSTEM RESPONSE RECORDING WITH MED-EL CLINICAL SYSTEM

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Introduction: *In some patients the evaluation of presence and excitability of the auditory nerve before cochlear implantation can be difficult and a precise patient evaluation cannot be always performed with standard methods. Electrophysiology and Objective measures, such as electrical auditory brainstem response (eABR), proved to be very useful in these cases. Patients with a positive response on the eABR recording pre-operatively are considered good candidates forcochlear implant (CI) as the integrity of the auditory pathway can beconfirmed.*
Objective: *The goal of the study is to evaluate promontory eABR with the MED-EL clinical system in CI candidates who underwent CI implantation.*
Materials/patients & methods: *Promontory eABR recording was performed in n=15 CI candidates. A trans-tympanic stimulating electrode with rounded-bended tipwas placed on the promontory or round window niche. The electrical stimulation pattern was generated by the MED-EL Stimulator Box and operatedby the MED-EL-clinical software. An external Evoked Potential (EP) recording device was used to collect eABR response.With the increasing stimulating amplitude fashionthe presence of electrophysiological response was recorded.*
Results: *Until now the promontory eABR was recordable in every subject. Thestatistical analysis of amplitude and latency of wave eIII and wave eV on the eABR recordingwas performed.*
Conclusion: *Promontory eABR with the MED-EL clinical system is simple to perform with the MED-EL clinical software and an external EP recording device without any limitations.The data suggests that this method can be valid in a selection process for CI implantation in any questionable CI candidate, including the children.*

SPEECH PERCEPTION TESTING WITHOUT THE SOUND BOOTH

Saji Maruthurkkara

Cochlear Ltd, Sydney Australia

Introduction and objective: *Speech perception testing is routinely conducted in many cochlear implant clinics during programming sessions. The speech test scores helps in comparing pre and post implant performance to determine benefit with the implant. It helps in the rehabilitation planning, programming or troubleshooting of issues by monitoring performance trend over time. It plays a critical role when device malfunction is suspected. In some countries it is also required for obtaining reimbursement or is an important part of medical records.*
Performance testing is usually conducted in a sound treated room; however, since fitting is not usually conducted there, the need to transfer the recipient to the sound booth causes inconvenience. Sometimes speech tests are also not conducted due to the non-availability of the sound booth.
ASSE Coala allows speech tests to be conducted with Nucleus cochlear implant recipients without the need for a sound booth. The signal is presented to the CP910 sound processor via the personal audio cable from a computer and the signal is calibrated by the programming pod connected to the processor. The study aimed at comparing the speech test scores with ASSE Coala and the same tests in a sound booth.
Methods: *15 subjects tested with CNC words @60dB in booth and also with ASSE Coala.*
Results: *No significant differences were found between the speech test scores in booth and ASSE Coala. The subjective feedback from clinicians and recipients will be discussed.*

THE NEED AND FEASIBILITY OF CAPTURING DATALOGS AT HIGHER GRANULARITY

Saji Maruthurkkara

Cochlear Ltd, Sydney Australia

Introduction and Objective: *The Nucleus CP900 series sound processor enables the clinician to view the datalogs from the recipient. The time on air, time in speech, accessory usage and program usage is helpful for counselling. The changes made to volume and sensitivity is helpful for programming. The datalogging information is also useful for habilitationists. Currently, clinicians are able to view the averaged data from the last programming session to the next. The feedback from clinicians has been that datalogging could be made even more useful if the data could be obtained at a more granular level. Such granular data would also be useful for recipients or their carers to monitor device usage. Since granular datalogs is not available in most other devices, the level of granularity required and the specific use cases are unclear.*
A novel method was developed that allows storage and retrieval of datalogs at a more granular level. However, more granular the data is made the more it impacts the size of data that can be stored. This study aimed at
1) evaluating the need for and level of granular datalogs for recipients and clinicians and
2) to test the feasibility of obtaining granular datalogs with cochlear implant recipients.
Methods: *A survey was conducted with clinicians, parents of paediatric recipients and adult CI recipients from all over the world on the potential benefits of having access to more detailed datalogs. A clinical study was conducted to test the feasibility of obtaining granular datalogs using a novel method of datalog capturing. Data was recorded from ten adults and seven paediatric cochlear implant recipients using the CP900 series sound processor.*
Results: *The survey results showed that parents of paediatric recipients, and clinicians valued the availability of granular datalogs. The clinical study results showed that it was feasible to collect detailed datalogs using the novel datalogging method.*

PRE-OPERATIVE MEASUREMENT OF AUDITORY EVOKED CORTICAL RESPONSES IN ADULT COCHLEAR IMPLANT CANDIDATES

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Introduction: *There is significant variability in hearing outcome after cochlear implantation (CI). Auditory evoked cortical responses (ACR) allow objective assessment of the auditory pathway.*
Aim: *To determine the feasibility of recording ACRs in adults with bilateral profound hearing loss prior to CI surgery.*
Patients and methods: *Six post-lingually deafened and one pre-lingually deafened subject with median age of 64 years (range 47-77) were tested. The median duration of hearing loss and profound hearing loss was 55 years (range 37-75) and 3 years (range 0.5-50) respectively. Median pre-operative residual hearing at 250 and 500 Hz was 95 dBHL (range 73-105).*
Testing was conducted with a unilateral hearing aid set at the comfortable listening level. Speech perception was tested with Bamford-Kowal-Bench (BKB) sentences in quiet presented at 70 dBA. Stimuli for ACR measurements consisted of the spondee /ba/at an intensity of 30 dBA sensation level. Morphological characteristics of ACRs recorded at fronto-central channels are presented.
Results: *Median BKB score in quiet was 0% (range 0-44). Robust ACRs were recorded in all seven subjects. The N1-P2 components dominated the response with an absent P1 in four subjects. The pre-lingually deafened subject had N1 and N2 components whilst P1 and P2 were absent.*
Conclusion: *Despite poor speech perception and long duration of deafness it was possible to record ACRs in all CI subjects. ACRs may be useful in the pre-operative assessment of CI candidates. We will also present longitudinal data on the development of these responses after surgery.*

THE ACOUSTIC CHANGE COMPLEX AS AN OBJECTIVE MEASURE OF ELECTRODE DISCRIMINATION IN ADULT COCHLEAR IMPLANT USERS

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Introduction: *The electrically evoked acoustic change complex (eACC) has been recorded in Nucleus users in response to a change in stimulating electrode and has been correlated with hearing performance.*
Objective: *To determine the feasibility of measuring the eACC in cochlear implant (CI) subjects with other CI systems and measure correlation with behavioural discrimination.*
Patients and methods: *Seven advanced bionics (AB) and two Medeladult implant users underwent testing. Stimulation level was at the most comfortable level and electrode pairs were loudness balanced. Stimuli for the eACC recording consisted of biphasic electrical pulses of 800 ms duration. In the test condition there was a change in stimulating electrode at the stimulus midpoint. The first control condition consisted of stimulation at a subthreshold level and the second control consisted of stimulation with no change. Stimuli were delivered at a rate of 0.51 Hz with 300 trials per electrode pair. Electrophysiological responses were measured with 64 scalp channels and 2 mastoid channels. CI artefact was removed with filtering and joint decorrelation. Behavioural electrode discrimination was measured using a 3-interval, 2-alternative forced choice task with 10 repetitions per electrode pair.*
Results: *Despite the presence of CI artefact the eACC could be visualized in the test condition but was absent in the control conditions. The presence of the eACC was correlated with behavioural electrode discrimination.*
Conclusion: *The eACC can be recorded in Medel and AB users to objectively assess electrode discrimination. A study to measure the eACC development after surgery to assess brain plasticity is currently on-going.*

OBJECTIVE ESTIMATION OF THE BONE CONDUCTION HEARING THRESHOLD

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Introduction: *Objective audiological measurements are very important in accurate audiological diagnosis. In everyday practice ASSR and BERA examinations are performed with measuring air conduction threshold. However in presence of air- bone gap these examinations are not sufficient.*
Objectives: *The aim of our study was to determine the accuracy of bone conduction measures in ASSR and CERA examinations.*
Materials/patients & methods: *10 persons with normal hearing and 10 patients suffering from conductive hearing loss were involved in the study. Typanometry, pure tone audiometry, ASSR and CERA examinations were performed, both air conduction and bone conduction were measured. Subjective and objective results were compared.*
Results: *According to our results there is no significant difference between subjective and objective hearing threshold. The results of different measuring techniques are correlated with each other.*
Conclusion: *Determine both air conduction and bone conduction hearing threshold with objective audiological methods gives the opportunity to have accurate audiological diagnosis in any kind of hearing loss in cases of small children and not cooperating adults as well.*

A VOLTAGE TELEMETRY TECHNIQUE FOR ESTIMATING COCHLEAR IMPLANT ELECTRODE ANGULAR INSERTION DEPTH

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Introduction and objective: *The depth of cochlear implant electrode insertion may be correlated to the extent of residual hearing preservation experienced for cochlear implant recipients. The need therefore exists for an intraoperative method for determining angular insertion depth in real time. A technique to do this, which utilises the implant's on board voltage telemetry amplifiers, was proposed and tested. The study presented here aims to verify the technique.*
Methods: *It is well established that the scala tympani is the primary conduction pathway for electrical current from scala tympani electrodes. However finite difference electrical modelling has shown that there is sufficient current flowing across the bony wall separating the cochlear turns to have a measureable effect on the electrical potential in the basal turn. This has been confirmed in bench trials with porous cochlear models as well as temporal bone insertions*
The technique employs wide bipolar stimulation between the most apical electrode and a more basal indifferent electrode. Voltage recordings are made in real time from more basal electrodes. The voltage measured in the basal turn, when plotted as a function of electrode position, has a maximum at a position adjacent to the tip electrode in the upper turn.
A study, underway at Oslo University Hospital, captures synchronized real time fluoroscopy and voltage telemetry data during the electrode insertion phase of cochlea implantation. The estimated angular insertion depth provided by each method will be compared. Additional telemetry measurements, following fixation, are performed for characterisation and optimisation purposes.
Results and conclusion: *Data from this study as well as from the in vitro work will be presented and discussed.*

IMPEDANCE MEASURES FOR SUBJECT-SPECIFIC OPTIMIZATION OF SPATIAL SELECTIVITY

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The Phased Array (PA) strategy has been proposed to improve the spatial selectivity of Cochlear implant (CI) stimulation by simultaneously activating all electrodes of the array. It however assumes that the inner ear is purely resistive and that electrical fields from different electrodes add linearly which might not hold especially at high frequency. Besides, the estimation of contact impedances is made by linear extrapolation of transimpedance measures. This study aims to evaluate these assumptions in order to better understand the electrical properties of the inner ear and propose alternatives to optimize electrical stimulation.
Several types of impedance measurements using sinusoidal or pulsatile wave forms were carried out in nine users of the Advanced Bionics CI as well as In vitro.
Transimpedance measures underlined the presence of an internal parasitic capacitance effective at high frequencies whichyields imperfect summation of the electrical fields at the onsets and offsets of biphasic pulses. For three subjects, an additional capacitive behavior, maybe arising from partial polarization of inactive electrodes was observed in the low (< 1 kHz) frequency region. These observations suggest that pulses with shallower transients and with a limited spectral content could be advantageously used in multipolar strategies.
A simple equivalent electrical model was used to describe the contact impedances. This model provided a better fit than previous attempts made in the CI field, thereby providing a way to estimate the access resistance of each electrode. Possible approaches to apply these findings to the optimization of the phased array strategy will be discussed.

ELECTROPHYSIOLOGIC DETECTION OF SCALAR CHANGING PERIMODIOLAR COCHLEA ELECTRODE ARRAYS: A FOLLOW-UP STUDY

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Introduction: *The position of the cochlea electrode array within the scala tympani is essential for an optimal hearing benefit. An intraoperative NRT-ratio was established, which can provide information about the intraoperative intracochlear electrode array position for perimodiolar electrodes. The aims of this study were to verify the NRT-ratio for straight electrode arrays and the longterm reliability for the NRT-ratio in perimodiolar electrodes.*
Materials and Methods: *In a retrospective controlled study in a Tertiary Referral Center the electrophysiological data sets of 142 patients with implanted Nucleus Contour Advance electrodes were enclosed. Intraoperative and up to year follow up Auto-NRTs were evaluated. A NRT-ratio was calculated by dividing the average Auto-NRT data from electrode 16-18 with the average from electrode 5-7. Using a flat panel tomography system, the position of the electrode array was certified radiological.*
Results and significance: *31 patients with perimodiolar electrodes with one year follow-up data were included in the study. Eleven patients showed regular follow-up NRT-ratio with a confirmed electrode position. 14 patients showed miss matches between the NRT-ratio and the radiological position. These patients were highly variable in the terms of duration of deafness and neural spectrum disorders. A good correlation between the NRT-ratio and the radiological position was seen in 65%.*
Conclusion: *The NRT-ratio can be used to determine the intracochlear position of the electrode array for perimodiolar electrodes. Intraoperative the NRT-ratio predicts the array position within the cochlea highly reliable for perimodiolar electrodes. We showed that after six months and a year the NRT-ratio remains unchanged in most of the cases and shows a good correlation to the radiological determined position of the array. Nevertheless the condition of the neural structures is highly important for reproducible responses. Limited validity is given in patients with degenerative and structural neural disorders.*

EXPERIENCES WITH THE NRT-RATIO IN SLIM STRAIGHT NUCLEUS ELECTRODES – A MULTI-CENTER STUDY

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Introduction: *The position of the cochlea electrode array within the scala tympani is essential for an optimal hearing benefit. An intraoperative NRT-ratio was established, which can provide information about the intraoperative intracochlear electrode array position for perimodiolar electrodes. The aims of this study were to verify the NRT-ratio for slim straight electrode arrays.*
Materials and methods: *In a retrospective controlled study in a Tertiary Referral Center the electrophysiological data sets of 50 patients with measured intraoperative Auto-NRTs were evaluated. All patients were implanted with a Nucleus slim-straight electrode. The NRT-ratio was calculated by dividing the average Auto-NRT data from electrode 16-18 with the average from electrode 5-7. Using a flat panel tomography system (HRCT), the position of the electrode array was certified radiological.*
Results: *By electrophysiological evaluation 48 patients were detected without a scalar change was rather improbable. In two patients, a scalar change was electrophysiologically probable. Radiologically two patients were identified with an electrode translocated into scala vestibuli.*
Conclusion: *The NRT-ratio can be used to evaluate the intracochlear position of the electrode array for perimodiolar electrodes. Related to a low sensitivity/specifity ratio the NRT-ratio seems to be electrode depending and not reliable for slim straight electrode arrays.*

REVISION SURGERY IN COCHLEAR IMPLANT PATIENTS WITH ELECTRODE MIGRATION

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Introduction: *Cochlear implantation is a safe procedure with a low risk for major complications. Migration of the electrode can be associated with vertigo and decreased speech perception, and can be observed in both straight and perimodiolar electrodes. Revision surgery is indicated if electrode migration is symptomatic and affects the patients outcome.*
Materials and methods: *Between January 2014 and November 20154 patients presented with either vertigo or performance drop several years after cochlear implantation in our institution. The patients received either perimodiolar electrode arrays (Nucleus Contour advance, Helix) or straight electrodes (Nucleus slim straight, Advanced Bionics IJ). The electrode array position was observed radiologically by the surgeon and 2 radiologists using a Flat Panel Tomograph (Philips Allura) or a high resolution CT scan. The insertion depth angle was estimated on the postoperative scans and compared with the scans performed on the day of consultation.*
Results: *Four patients showed electrode migration over 20°. Two patients reported recurrent vertigo after middle ear infection and two patients reported a distinct perfomance drop. Changes of impedences were seen in all patients. All patients underwent revision surgery via an enaural access to the middle ear. In all patients the electrode could be repositioned. Postoperative the correct position was verified radiological.*
Discussion: *Electrode migration seems to be more common than expected and can cause several problems for the patients. Proper fixation of the electrode array is required to avoid electrode migration. The enaural revision with repositioning of the electrode and sealing of the cochleostomy is an easy way to relief the patients' symptoms and restore the ability for better speech perception.*

COMPARISON OF COCHLEAR IMPLANT FITTING PROCEDURES – PRELIMINARY RESULTS OF A MULTICENTER STUDY

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An important task in the context of cochlear implant supply is adjusting the speech processor to the individual needs of patients. Clinical fitting procedures are based on psychoacoustic and objective audiological measurements. But there is no generally accepted method and parameter selection is often dependent on the experience of the clinician.
Cochlear introduced the NucleusFittingSoftware(NFS) to standardize the procedure and allow less experienced audiologists an effective adjustment. The method is based on the individual threshold profile of the electrically evoked compound action potentials of the auditory nerve (ECAP), as well as simple psychoacoustic estimates of loudness and pitch of the maps created.
A prospective double blind study at three CI centers with longtime experience in CI treatment investigates whether this simplified method leads to comparable results, as the established clinical routines. The NFS modifications NFS-5, using 5 postoperatively measured ECAP thresholds (TNRT) and NFS-22, with TNRTs from all electrodes are compared to the established clinical procedures. 48 unilateral implanted, postlingually deaf adults with ≤15 years of severe to profound deafness are divided into 6 groups. In these groups, the fitting procedures are permuted in ABCA-order. The fifteen month study period per patient allows at least a three-month familiarization with each of the different maps. Data collection includes subjective assessments as well as measurements of hearing thresholds and speech intelligibility in quiet and noise.
34 participants have been enrolled so far, including seven drop-outs (four hospital-related protocol deviations, three NFS-procedure related). A preliminary analysis of the speech performance results did not reveal significant differences.

THE USE OF MEDICAL IMAGE RECONSTRUCTION IN THE PREPARATION OF THE SURGERY OF THE EAR – SPARING THE FACIAL NERVE

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Introduction: *The availability of powerful computers and the possibility to use free open source software to process medical images is changing the way we prepare for surgeries. The ear is no exception. One of the key points of various ear interventions is to spare the facial nerve. If we can properly visualize and can actually measure distances of selected anatomical landmarks and the facial nerve before the intervention the nerve can be spared with a higher possibility.*
Objectives: *To show how the above procedure can be done, what are the computational and human resources we need. We also present a few introductory cases.*

Materials & methods: *During this work we used the MR and/or CT scans that were taken with the standard protocols at various locations in our country. To do preoperative image reconstructions, we used the free, open source software 3D Slicer. Before the surgical interventions the reconstructed models were carefully inspected by the surgeon.*
Results: *In extreme cases, where the patient's anatomical situation was different from the normal anatomy the results were more than satisfying, since the surgeon could plan the intervention in 3D before the actual operation took place, thus the facial nerve could be spared. The time it took to prepare the 3D models is a few ten minutes, which is acceptable.*
Conclusion: *A wider scale use of medical image reconstruction makes the ear surgeries less prone to complications, since the surgeon can explore the patient's anatomy before the intervention and shortens the time of hospitalization.*

COMPARATIVE ANALYSIS OF ELECTROPHYSIOLOGICAL AND PSYCHOPHYSICAL PARAMETERS IN COCHLEAR IMPLANT USERS WITH AND WITHOUT KNOWN GENETIC BACKGROUND OF HEARING LOSS

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Introduction: *The research of the genetic background of various hearing-related disorders is a relatively new and still rapidly evolving common field of molecular biology and clinical sciences. More and more pathways are known how various genetic defects cause hearing loss, their clinical data and thus the progress of the audiopathy is well established in a few cases.*
Objectives: *Our aim was to investigate if and how the genetic background of the hearing loss influences the electrophysiological and psychophysical parameters of the patient during the use of the cochlear implant.*
Patients and methods: *40 subjects were selected aged between 2-4. All were diagnosed with prelingual hearing loss either with 1.) only with 35delG mutation of the GJB2 gene, 2.) other, non-35delG genetic mutations or 3.) different or unknown origin of hearing loss. We evaluated their intraoperatively evoked stapedius reflex threshold levels, impedance telemetry, postoperative threshold- and comfort levels as well as the results of auditory and speech tests.*
Results: *The intraoperative stapedius-reflex thresholds and the speech audiometry tests all showed the best results in group 1.). By follow up it was also revealed that the hearing and speech development shows the best results in the same cohort of patients.*
Conclusion: *Our findings indicate that the common GJB2 35delG mutation can also serve as a benefit compared to other hearing loss causing genetic mutations and hearing losses of unknown origin. This group of patients show significantly different psychophysiological and electrophysiological parameters and better speech and hearing performance during the follow up period.*

IMPROVEMENT IN NERVE SYNCHRONISATION WITH ELECTRICAL STIMULATION OVER TIME IN PATIENTS WITH AUDITORY NERVE ANOMALIES

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Introduction: *Electrically Evoked Compound Action Potential(ECAP) represents a synchronous response from electrically stimulated auditory nerve fibres and is essentially the electrical version of Wave I of the ABR. Studies have reported improvement in neural synchronisation measured through ECAP measurementsin children/adults with no nerve anomalies (Moura. et al. 2014., Caldas, et al. 2015). Through this study we aim to see ifindividuals with nerve anomalies have a similar result.*
Objective: *To observe improvement in auditory nerve synchronisation post electrical stimulation over time in children with auditory nerve anomalies like auditory neuropathy spectrum disorder and hypo-plastic auditory nerve and compare the results.*
Methods:
1. Ten children in the age range of 2-6 years in both ANSD (group1) and hypo-plastic nerve (group 2) participated in the study.
2. Extensive pre-implant evaluation process after an adequate hearing aid trial, included TT-EABR and cortical potentials. After positive results in these two teststhey were considered for cochlear implantation with counselling ofexpected outcomes.
3. Intra-operative ECAP measurements were done in auto and manual mode for 5 electrodes across the array.
4. Retrospective analysis was done on ECAP measurements post 12 months of electrical stimulation to look for any improvement in neural synchronisation over time. We looked at the change in T-NRT values and N1-P1 amplitude at T-NRT level.
5. The results of group 1 were compared with group 2 and data was analysed statistically.
Results: *1. Electrical stimulation over a period of time improved neural synchronisation of auditory nerve in children with auditory nerve anomalies.*
2. Preliminary analysis showed a significant improvement in ANSD group when compared to hypo-plastic nerve group.
Conclusion: *Overall there is an improvement in neural synchronisation post electrical stimulation over time in children with auditory nerve anomalies, similar to that reported in cochlear implant users without any nerve anomalies.*

CHARACTERIZATION OF ELECTRICALLY EVOKED COMPOUND ACTION POTENTIALS IN PATIENTS WITH A HYBRID COCHLEAR-VESTIBULAR IMPLANT

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Introduction: *Patients with bilateral vestibular loss suffer from a significantly reduced quality of life and have no adequate treatment option. By electrically stimulating the peripheral vestibular nerve, vestibular function can be partially restored (1).*
Objective: *To characterize electrically evoked compound action potentials (ECAPs) using electrodes implanted in the cochlea and in the peripheral vestibular system.*
Patients and methods: *Patients with bilateral vestibular loss and severe hearing loss received a hybrid cochlear-vestibular implant with electrodes targeting peripheral vestibular nerve branches (MED-EL, Austria) (2). We recorded amplitude growth and recovery functions in a small number of patients for three setups:*
1) cochlear-cochlear ECAPs by stimulating and recording with cochlear electrodes,
2) cochlear-vestibular ECAPs by stimulating with a cochlear electrode and recording with a vestibular electrode or vice versa, and
3) vestibular-vestibular ECAPs by stimulating and recording with vestibular electrodes. Electrical stimulation consisted of single biphasic pulses with Alternating Polarity and Masker-Probe artifact reduction to access ECAP morphology.
Results and conclusion: *We successfully recorded ECAPs for all setups. Cochlear-vestibular and vestibular-vestibular ECAPs exhibited similar morphology as cochlear-cochlear ECAPs with two peaks. However, peak-to-peak voltages for cochlear-cochlear ECAPs were markedly larger than for the other setups. Amplitude growth functions for all setups displayed sigmoidal shape with distinct segments below and above threshold. Recovery functions for cochlear-cochlear ECAPs had a clearer exponential shape than the other setups. These results suggest that electrode placement during implantation could be guided with ECAP. Further tests and analysis might reveal new insights about the morphology of inner ear ECAPs.*

1. *Merfeld DM, Lewis RF. Replacing semicircular canal function with a vestibular implant. Current opinion in otolaryngology & head and neck surgery 2012; 20 (5): 386–392.*
2. *Guinand N, van de Berg R, Cavuscens S, et al. Vestibular Implants: 8 Years of Experience with Electrical Stimulation of the Vestibular Nerve in 11 Patients with Bilateral Vestibular Loss. ORL 2015; 77 (4): 227–240.*

CLINICAL VALIDATION OF A PERSONALIZED MODEL OF THE ELECTRICALLY STIMULATED AUDITORY NERVE

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Introduction: *Due to differences in the interface between the electrodes and the auditory nerves, the best settings of the cochlear implant (CI) may differ for each user. For example the exact position of the electrodes and the amount of functional auditory neurons might differ significantly between different CI users.*
Methods: *In order to improve the fitting of CIs and to understand the electrode-nerve interface, a user specific model of the auditory nerve activity has been developed. This work presents the basic components of the model:*

1) A 3D finite element method to estimate the voltage distribution in the cochlea,
2) An auditory nerve model based on multi-compartment Hodgkin-Huxley type equations. The model has been fitted to electrophysiological measures in CI users to predict their most comfortable levels of CI users.
10 Advanced Bionics CI users participated in the validation of the model. The research software Volta (Advanced Bionics ERC, Hannover, Germany) was used to perform recordings from the backward telemetry of the implant. For each CI user the voltage distribution was measured. Additionally, amplitude growth (AGF) and spread of excitation (SOE) functions were obtained using an artifact rejection forward masking paradigm at three electrode locations. The model has been personalized by fitting its outcome to predict the individual voltage distributions, AGFs and SOEs with minimal error. After the fitting, the model has been used to predict the most comfortable levels of each CI user.
Results: *The modeling results show that a patient specific model can improve the predictions of the most comfortable levels in comparison to a non-personalized model.*

PHYSIOLOGICAL AND PSYCHOMETRIC CHARACTERIZATION OF IPSILATERAL MASKING BETWEEN ACOUSTIC AND ELECTRIC STIMULATION THROUGH COCHLEAR IMPLANTS

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Everyday more people with residual hearing receive cochlear implants (CIs) to obtain electroacoustic stimulation (EAS). However, it is still unknown how the acoustic and electric stimulation modalities interact. This work characterizes this interaction through simultaneous masking, cone beam computer tomography (CBCT) and electrophysiological responses.
3 Advanced Bionics Mid-Scala electrode users with ipsilateral residual acoustic hearing at low frequencies participated in the study. Masking effects between electric and acoustic stimulation were measured psychophysically and electrophysiologically.
The psychophysical task consisted of measuring the elevation in the threshold of audibility of a probe in the presence of a masker. Electrical stimulation was delivered using unmodulated pulse trains directly presented via a CI-Research-Interface. Acoustic stimulation was delivered through pure tones using an earphone. Electrode insertion depth and residual hearing were assessed based on CBCT scans and using the Greenwood equation.
Electrophysiological measures consisted of recordings of the auditory nerve activity using intracochlear electrodes for an acoustic (A), a simultaneous acoustic and an electric tone (A+E) and an electric pulse train (E). The derived measure (D) was obtained subtracting the responses between the A+E and the E responses. Finally the interaction was estimated by comparing the D and the A responses.
Acoustic electric interaction was observed only in one CI user having large residual hearing. A 3 dB and a 6 dB threshold elevation were observed psychophysically and electrophysiologically respectively. From these results it seems that the interaction between acoustic and electric stimulation can be measured electrophysiologically, however the sensitivity of this measure underestimates the psychophysical measures.
This work was supported by the DFG Cluster of Excellence EXC 1077/1 "Hearing4all".

DECODING SPEECH SOUND SOURCE DIRECTION FROM ELECTROENCEPHALOGRAPHY DATA USING COCHLEAR IMPLANT VOCODER SIMULATIONS

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It has been shown that it is possible to decode the direction of the incoming speech presented to a subject from single trial EEG data. However, it is unknown how the performance of such a decoder is affected by the decrease in spectral resolution produced by a cochlear implant (CI).
5 normal hearing subjects participated in the present study. Speech from two audio stories was presented from loudspeakers at –45 and +45 degrees azimuth and 0 degrees elevation. Subjects kept their eyes fixed to the front while a 32-channel EEG was recorded. EEG data were segmented into 1 second epochs with 50% overlap. A short time fast Fourier transform was used to decompose the recordings into 0-4 Hz, 4-8 Hz, 8-16 Hz and 16-32 Hz bands. For each band the power was taken. A support vector machine was trained on these features using 5 fold cross-validation. The output of the classifier was the angle of the incoming sound source.
The experiment was repeated using a sine-vocoder and a noise-vocoder. The noise-vocoder causes spectral smearing and therefore a worse spectral resolution than the sine-vocoder.
The results show a 99.19% accuracy in detecting the angle of the incoming sound using the original sounds. The performance dropped to 98.03% and 96.36% using the sine-vocoder and the noise-vocoder, respectively. The ability to discern the direction of an incoming sound using short single-trial data segments seems to be feasible using VoCoder simulations. However, the accuracy drops when the spectral resolution becomes worse.

TO MONITOR COCHLEAR FUNCTION DURING COCHLEAR IMPLANTATION AND DETERMINE CORRELATIONS WITH POSTOPERATIVE ACOUSTIC HEARING

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Background: *Cochlear response telemetry measures cochlear function directly from cochlear implant electrodes. We have adaptedthis system to provide real-time cochlear response telemetry (RT-CRT) monitoring of a patient's acoustic hearing as the cochlear implant electrodearray is inserted.*
Methods: *Eighteen subjects (1 child and 17 adults) with sloping high frequency hearing loss were implanted with Cochlear Ltd slim straight arrays (CI422/CI522). Tone bursts (500 Hz, 100-110 dB) were presented at 14 Hz continuously during the array insertion. RT-CRT amplitudes were correlated with surgical maneouvres recorded on the video from the operating microscope and with postoperative pure tone audiograms.*
Results: *Despite an excellent overall rate of complete orpartial hearing preservation (79%), RT-CRT identified that in 47% of these implantations there were transient or permanent reduction in the amplitude of the cochlear microphonic (CM). Patients with a preserved CM at the end of insertion had on average 15 dB better low frequency hearing preservation. The CM amplitude was most vulnerable during the last few millimeters of insertion or when in advertent movement of the array occurred after full insertion. Physical contact/elevation of the basilar membrane is hypothesized as a likely mechanism of hearing loss rather than overt physical trauma.*
Conclusion: *RT-CRT can be used topredict early postoperative hearing loss and to potentially refine surgical technique. In the future, feedback of RT-CRT may prove to be a valuable tool for maximising preservation of residual hearing or providing feedback onelectrode contact with the basilar membrane.*

INTRAOPERATIVE TESTING OF COCHLEAR NUCLEUS ELECTRODES – CI512 VS. CI532

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Introduction: *The new Nucleus CI532 electrode from Cochlear Ltd. is significantly slimmer than the earlier types of electrodes and this might be advantageous with regards to atraumatic electrode insertion. The CI532 electrode is attached to a recently developed external sheath that guides the electrode into the cochlea during insertion. In contrast, the CI512 electrode is mounted with an internal guidewire due to which it is thicker.*
Objectives: *Comparison of cochlear implants mounted with different electrodes (Nucleus CI512 vs. CI 532) by intraoperative electrophysiological testing.*
Materials/patients & methods: *Intraoperative neural response telemetry (NRT) and electrical stapedial response telemetry (ESRT) results of patient who were implanted with Nucleus CI512 (total of 54 ears) and Nucleus CI532 (total of 20 ears) were compared. The measurements were made with 6 out of 22 channels in even tonotopic distribution (i.e. channel No 2; 6; 10; 14; 18 and 22).*
Results: *NRT and ESRT on average proved to be lower in all channels of CI532. NRT and ESRT in CI512 and ESRT in CI532 constantly increased from the apical to the basal channels while ESRT in CI532 was low in the apical and comparably high in the basal channels in several cases.*
Conclusion: *Our results prove that both electrodes can be applied successfully. Because it is slim and curved, the CI532 electrode gets in closer contact with the neural structures in the modiolus especially in the more medial and apical regions, which results in lower NRT and ESRT compared with CI512. Higher ESRT and NRT in the basal region may result from loss of perilymph during insertion caused by the volume*

of the sheath. The slim electrode can be easily inserted into the cochlea with assistance of the external sheath to make the procedure less traumatic.

INTRACOCHLEAR SOUND PRESSURE MEASUREMENTS WITH ANEWLY DEVELOPEDMEMS CONDENSER-MICROPHONE-BASED SENSOR

Flurin Pfiffner[1], Lukas Prochazka[2, 3], Dominik Péus[1], Ivo Dobrev[1], Adrian Dalbert[1], JaeHoon Sim[1], Dominik Obrist[4], Joris Walraevens[5], Francesca Harris[5], Christof Röösli[1], Alexander Huber[1]

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Introduction: *Measurements of intracochlear sound pressure (icsp) are valuable for experimentally evaluatingthe conductive hearing mechanism. However, existing icsp measurement methods are difficult mainly due to laborious sensor preparation, sensitivity changes related to mechanical perturbations,complexity of experimental setup and the limitations of thesensor's signal to noise ratio.*
Objective: *We present a new intracochlear acoustic receiver (ICAR). Our aim is to:*
1) fabricate an ICAR,
2) perform a number of experimentsto verify the ICAR performance and
3) determine icsp in human temporal bones.
Materials and methods: *The presented ICAR concept is based on a MEMS condenser microphone with an additional protective passive diaphragm that hermetically seals the MEMS condenser microphone against the liquid working medium on the receiving side.*
Results and conclusion: *Three ICARs have been successfully fabricated. The transfer functions between the sound pressures near the tympanic membrane and the intracochlear pressures in the scala tympani have been measured in 5 human temporal bones. Sufficient repeatability was achieved across the ICAR's and data is in accordance with literature. The ICAR sensitivity difference between pre- and post-experiment is less than 2 dB over the whole frequency range. Results confirm that a MEMS condenser microphone is a promising technology for measurement of icsp. The development of an ICAR prototype II with an improved sensitivity and with several diaphragms is planned.*

INVESTIGATION OF THE SHEEP MIDDLE EAR TRANSFER FUNCTION AND INTRACOCHLEAR PRESSURE

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Background: *Animal models are frequently used for the development, testing and establishment of new hearing devices. The middle ear and cochlea of many extensively examined animals such as rodents and cats differ significantly in dimension from that of humans. The sheep cochlea has been shown to be similar in its anatomical dimensions to the human cochlea. It has been used as a surgical training model for cochlear implants (CIs), but little is known about its function. The current study investigates the middle ear transfer function and intracochlear pressure in sheeptemporal bones, with the aim of characterising the usefulness of sheep as a future experimental model for implantable hearing devices.*
Method: *In this experimental study, fresh sheep temporal bones were used. Firstly, velocities of the ossicles were measured with a laser Doppler vibrometer (LDV) in response to acoustic stimuli while sound pressure in the external auditory canal was recorded. Secondly, intracochlear pressure was recorded in the same temporal bones with the same stimuli using a newly-developed MEMS condenser hydrophoneat different locations within the inner ear. Subsequently, micro-computed tomography and 3D reconstructions of the temporal bones were used to confirm the measurement sites.*
Results: *The measured umbo velocity, normalized for the ear canal pressure, was similar to previously reported data in humans at low frequencies (i.e. <2 kHz); however, it was larger at higher frequencies. Middle ear pressure gains, derived from measurements in the scala tympani and in the external ear canal, werein agreement with our measurements of the middle ear ossicles, indicating larger gains at higher frequencies.*
Conclusion: *This work provides quantitative data regarding the middle ear transfer function and intracochlear pressure in sheeptemporal bones. The results: are compared to measurements in human temporal bones and published data in other species. Despite the anatomical differences with humans, particularly regarding the middle ear, we conclude that sheeparea comparative large animal modelwhich is applicable to the research and development of implantable hearing devices.*

MEASURING BENEFITS FROM TRANSFORMATION OF LOST SEGREGATION CUES IN HEARING DEVICES WITH ACOUSTICAL CHANGE COMPLEX

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Can transformation of lost Temporal Fine Structure (TFS) cues help people with hearing impairmentin situations that require TFS cues? Moreover, what does the Acoustical Change Complex (ACC) reveal about the efficiency of the transformation of TFS cues? Many recent studies have shown that age and sensorineural hearing loss limits the ability to perceive and utilize Temporal Fine Structure (TFS) cues. Moreover, the TFS cues seem to facilitate segregation of voices. Finally, until recently, cochlear implant users were also missing TFS cues, as most stimulation strategies discarded all TFS cues.
The TFS1 listening test [1] is very difficult for people with mild-to-moderate hearing impairment. The present study investigates extraction of the unavailable TFS cues and transformation of TFS to envelope cues (TFS2ENV) and measures the benefit with the TFS1 test. The TFS2ENVtransformation enables the people with hearing impairment to perform the TFS1 test with similar performance as people with normal hearing.
The present study compares the behavioural TFS1 test results with the ACC responses to investigate to which extent TFS2ENVprocessing restores ACC amplitude and timing back to those of people with normal hearing.Moreover, the present study investigates the modification of the TFS1 stimuli to improve recording of the acoustical change complex.
While TFS2ENVimproves discrimination tasks in the TFS1 test, it remains to be seen if the benefit also carries over to segregation of voices. For cochlear implants, it also remains to be seen if TFS2ENV provide supplementary benefits together with stimulation strategies that convey TFS.

1. B. C. J. Moore and A. Sek, "Development of a fast method for determining sensitivity to temporal fine structure," Int. J. Audiol., vol. 48, no. 4, pp. 161–171, Apr. 2009.

REPRESENTATION OF SPATIAL CUES PROCESSED WITH FINE STRUCTURE CODING VERSUS CONTINUOUS INTERLEAVED SAMPLING IN COCHLEAR IMPLANT USERS

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Background: *The fine structure coding strategy (channel specific sample sequences; CSSS) has been developed for cochlear implant (CI) users to improve the speech and music intelligibility using an improved processing of low frequency portions of stimuli spectra. Zero-points of the signal waveform trigger the electrical pulses which are weighted by the amplitude of the envelope. Thus, spatial cues might be better processed as well.*
Methods: *128-channels EEG recordings were performed on adult 5 bilateral CI users. Mismatch Negativity (MMN) amplitudes and latencies were analyzed for the conditions of*
1) white noise signals, and
2) sinosoidal tones; presented with ITDs of 0 and 1500 µs each. CSSS and CIS strategies were compared. 15 normal hearing subjects were measured as control group.
Results and conclusion: *Differences between 'deviant' and 'standard' stimuli show a clear discrimination of spatial cues. Neuronal sources were located in the auditory cortex. Consequences for the fitting of CI users are discussed.*

PREDICTING THE NATURE OF ELECTRODE USING OBJECTIVE MEASURES IN CHILDREN WITH AUDITORY BRAINSTEM IMPLANT

Rajeswaran R[1], Kameswaran M[2]

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Introduction: *One of the most challenging tasks in programming Auditory Brainstem (ABI) is to identify the auditory and non-auditory electrode, especially in children who do not have any auditory experience. Electrically Evoked Auditory Brainstem Re-*

sponse (eABR) is one of the most applied measurements in predicting the electrode type. In this study we also used Cortical Auditory Evoked Potentials (CAEP) to complement the eABR findings.
Objective: *To predict Auditory and Non-Auditory Electrode in children with ABI using eABR and CAEP.*
Methods: *Fourteen children with ABI were included in the study. All children sound processor were programmed using the traditional programming technique. Electrodes that elicited non auditory sensation were disabled. eABR were measured in all activated electrodes. CAEP were also performed on these subjects. Electrodes were grouped based on their location on the electrode pad. eABR and aided CAEP were performed in these groups of electrodes.*
Results: *Both auditory and non-auditory sensations were observed across subjects. eABR could be measured in most of the electrodes, yet could not be measured in few electrodes despite no non-auditory sensation. eABR morphology was variable across electrodes and subjects, we could record single peak, two peak and also three peak morphology. Aided CAEP was also recorded and the amplitude growth function of the response was consistent. Relationship between these two test will be discussed.*
Conclusion: *Electrophysiological measurement on children with ABI provides useful information for the audiologist, surgeons and therapist and the use of battery of test is recommended.*

PREDICTING THE NATURE OF ELECTRODE USING OBJECTIVE MEASURES IN CHILDREN WITH AUDITORY BRAINSTEM IMPLANT

Rajeswaran R[1], Kameswaran M[2]
[1]MERF Institute of Speech and Hearing, Chennai, India,
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ASSESSING THE FIRING PROPERTIES OF THE ELECTRICALLY STIMULATED AUDITORY NERVE USING A CONVOLUTION MODEL

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Introduction: *The electrically evoked compound action potential (eCAP) is a routinely performed measure of the auditory nerve in cochlear implant users.*
Objective: *Using a convolution model of the eCAP, additional information about the neural firing properties can be obtained, which may provide relevant information about the health of the auditory nerve.*
Materials & methods: *Guinea pigs with various degrees of nerve degeneration, and with or without neurotrophic treatment, wereused to directly relate firing properties to nerve histology. The same convolution model was applied on human eCAPs to examine similarities and ultimately to examine its clinical applicability.*
Results: *For most eCAPs, the estimated nerve firing probability was bimodal and could be parameterized by two Gaussian distributions with an average latency difference of 0.4 ms. In guinea pigs, the ratio of the scaling factors of the late and early component increased and the latency of the early component decreased with neural degeneration. In humans the ratio decreased with stimulation intensity, and latencies were shorter at the base compared to the apex. Assuming that the cochlear base exhibits more neural degeneration than the apex, the results are consistent for both species. Differences between guinea pigs and humans were observed, among other parameters, in the width of the early component: very robust in guinea pig, and dependent on stimulation intensity and cochlear region in humans.*
Conclusion: *We conclude that deconvolution of the eCAP is a valuable addition to existing analyses, in particular as it reveals two separate firing components of the auditory nerve.*

MODELLING THE PHYSIOLOGY OF SPIRAL GANGLION NEURON ELECTRO-STIMULATION

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The efficacy of electrical stimulation in cochlear implantation (CI) depends critically on the state of the nerve fibres interfacing with the array of electrodes inserted into the inner ear. Current research in the field focuses on improving that interface; biologically through increased 'bio-mimicking' of electrical stimulation strategies, pharmacologically with neuro-trophic or -protective drug coatings applied to the electrode array, or through parallel advances in signal processing.
We present a physiologically inspired model of Spiral Ganglion Neurons using Finite Element methods. This model aims to evaluate stimulation strategies and to determine the efficacy of other proposed improvements in devices. The data will be presented as interpretable-modelled outputs from different levels of the auditory brain pathways that can be used to generate specific hypotheses as to the benefits of different stimulation strategies, for example, in patients receiving CIs. This then allows for comparison and assessment using electrophysiological tests in CI patients.
The model incorporates relevant physiological characteristics that generate action potential and result in refractoriness, facilitation, accommodation and spike-rate adaptation. The model also allows for parametrization of ionic channels dynamics and position, geometry characterisation. We demonstrate how the model is validated from published physiological data and other available model data, as well as preliminary data from simulations based on physiological considerations.

NASAL SOUND PRESSURE AS VERIFICATION OF A BONE CONDUCTION IMPLANT

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Introduction: *The Bone Conduction Implant (BCI) is a new active transcutaneous bone conduction device, which both provides direct bone stimulation and lets the skin be intact. There is a need of controlling the implant before closing the wound during surgery and in follow up visits.*
Objective: *To investigate if nasal sound pressure (NSP) is an appropriate objective measure to verify the implant performance.*
Materials/patients & methods: *For 10 patients, the NSP was measured during surgery and in follow-up visits up to 12 months after fitting. The implant is stimulated electrically, transmitting vibrations throughout the skull and measured in the ipsilateral nostril as NSP.*
Results and discussion: *The NSP was found to be highly individual, and there are frequency dependent differences between the patients. Since the patient's position is not the same during surgery and in follow up measurements, a clear difference between these settings could be seen as well. On individual basis, the NSP is mainly the same in consecutive follow-up measurement indicating a stable transmission condition over time. The current setup, which is mainly a research tool, might be considered too complex to be used a clinical routine. Either a simplified battery operated stand-alone system can be developed, or an even more simplified acoustic method can be used, where the implant performance is verified by acoustic radiation from the implanted unit.*
Conclusion: *It is feasible to use NSP as a verification method of implant performance both during surgery and as a follow up investigation over time.*

INTRAOPERATIVE ELECTROCOCHLEOGRAPHY DURING COCHLEAR IMPLANT SURGERY

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Introduction: *Monitoring of ongoing cochlear and VIIIth nerve physiology has long been the goal during cochlear implant (CI) surgery. The use of electrocochleography (ECochG) has been the method of choice to isolate cochlear and neural potentials during implantation. Utilizing a long plateau tone burst stimuli, the ECochG potentials (cochlear microphonic, summation potential, compound action potential and auditory nerve neurophonic (1, 2, 3) can be captured to give the surgeon reasonable knowledge of cochlear integrity requiring only minimal acquisition time.*
Objective: *The aim of this study was to characterize a novel method for recording electrocochleographic activity directly from the CI electrode during the insertion process as well as extracochlear from the round window.*
Methods: *Intracochlear recordings were accomplished utilizing the implant electrode to recordrecordings as the implant was being placed. Extracochlear recordings were accomplished via placing a recording probe on the round window or promontory and continually recording during the implantation process. These techniques allow for continuous measurements to be made within close proximity to the ECochG generators.*
Results: *Pre-operative pure-tone audiometry, intra-operative ECochG, and post-operative pure-tone audiometry and ECochG data are presented. Correlation between ECochG and corresponding change in audiometric thresholds are discussed.*
Conclusion: *Our approach allows for real-time monitoring of cochlear and neural integrity via intracochlear and extracochlear recording techniques to detect cochlear changes during the insertion of the cochlear implant electrode. This technique has the potential for uses such as improving hearing preservation rates during CI surgery, monitoring cochlear health post-operativelyand prediction of post-operative speech recognition outcomes (4).*
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WAVE PROPAGATION ON THE SURFACE OF THE SKULL IN BONE CONDUCTION STIMULATION

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Background: *Bone conduction (BC) is an alternative to air conduction to stimulate the inner ear. Generally, the stimulation for BC occurs on a specific location from where it propagates to the ipsilateral and contralateral cochlea.*
Objective: *This study aims to investigate on wave propagation on the surface of the skull bone during BC stimulation for stimulation on the mastoid.*
Material&methods: *Measurements were performed in three human cadaveric whole heads. A bone anchored hearing aid (BAHA) was attached to a percutaneously implanted screw. The BAHA was directly driven with stepped-sine signals in the frequency range of 0.1–10 kHz for measurement in frequency domain, and two-cycle sine signals in the frequency range of 0.5-8 kHz for measurements in time domain. Simultaneously, skull bone vibrations were measured at multiple points on the skull using a Scanning Laser Doppler Vibrometer (LDV) system, and a 3D LDV system. The two recording methods were compared.*
Results: *The 3D velocity measurements confirmed the complex spatial and frequency dependence of the response of the cadaver heads indicated by the 1D data from the scanning LDV system: Rigid body was dominant below 1 kHz, and clear transverse traveling waves were observed above 2 kHz. The wave speed was about 450 m/s, and the corresponding trans-cranial time interval was 0.4 ms supporting the presence of transverse travelling waves.*
Conclusion: *Both scanning LDV and 3D LDV data showed standing waves dominanating at low frequencies, whereas transverse (i.e. out-of-plane) travelling waves with a speed of 450 m/s were observed above 2 kHz.*

QUANTIFICATION OF THE EFFECT OF PHYSIOLOGICAL CONDITION ON THE SOUND TRANSMISSION VIA THE MALLEUS-INCUS COMPLEX

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Introduction: *The malleus-incus complex (MIC) plays a crucial role in the hearing process, however, its transfer function, under physiologically-relevant acoustic stimulation, is still not fully elucidated. Measurements ofthe transfer function of the MIC are typically done on frozen temporal bones, which are generally accepted to be mechanically equivalent to fresh samples and living humans, however, there may still be significant physiological changes in the MIC transfer function with freezing.*
Objective: *This study investigates three-dimensional motions of the malleus and incus withfull six degrees of freedom (6 DOF) in frozen and fresh temporal bones.*
Methods: *The motion of the MIC was measured in sets of frozen and fresh cadaveric human temporal bones with intact middle-ear structures excited via a loud speaker, embedded in an artificial ear canal. Three-dimensional (3D) shapes of the middle-ear ossicles, obtained by sequent micro-CT imaging, were used to define an intrinsic (anatomical)coordinate system. The shape and motion data were combined to quantify the rigid body motions of the malleus and incus, as well as their relative motions, with full six degrees of freedom.*
Results and conclusion: *The preliminary results indicate that the hinged rotational motion is dominant at frequencies below 1.5 kHz, but the motion of the malleus and incus becomes complex, with clear relative motion,at higher frequencies, for both fresh and frozen temporal bones.Themagnitude of the relative motion between the malleus and incusis lower for frozen temporal bones, indicative of potential stiffening of the incudo-malleolar joint with freezing.*

AUDITORY AND AUDIO-VISUAL PROCESSING IN INDIVIDUALS WITH AUDITORY IMPLANTS: ELECTROPHYSIOLOGICAL FINDINGS IN COCHLEAR, AUDITORY BRAINSTEM AND AUDITORY MIDBRAIN IMPLANT PATIENTS

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Introduction: *Auditory brainstem implants (ABIs) andauditory midbrain implants (AMIs) are designed for electrical stimulation of the cochlear nucleus or the inferior colliculus to compensate hearing loss in individuals with neural deafness. However, only someABI/AMI patients are able to understand speech without lip-reading.*
Objective: *We performed an EEGstudy to better understand the variability in speech recognition across patients, covering the whole spectrum of today's available auditory neural prostheses. Specifically, we examined how electrical stimulation at different levels of the auditory pathway is related to cortical responses and hearing abilities in cochlear implant (CI), ABI and AMI recipients.*
Methods: *Patients (ABI, CI: N=6; AMI: N=2) of the Hannover Medical School and normal-hearing (NH) listeners (N=6) performed a speeded response task with basic auditory, visual and audio-visual stimuli.*
Results: *All groups revealed shortest response times (RTs) incross-modalconditions. Interestingly, ABI/AMI patients showed prolongedRTsforauditory and audio-visual stimuli compared to NH listeners, indicating a slowdown of auditory processing in those patients. Impaired auditory processing was confirmed by observations of prolonged latency and smaller amplitude of the N1 auditory event-related potential, and by lower speech recognition abilities in these patients. However, ABI patients showed a remarkable gain in performance for audio-visual compared to unisensory conditions, suggesting compensatory multisensory processing strategies. Consistently, visual modulation of the auditory N1 amplitude was strongly pronounced in ABI and CI patients.*
Conclusion: *Findings indicate enhanced audio-visual coupling in ABI and CI patients and could provide important implications for the optimization of stimulation and rehabilitation strategies.*

ECAP CHARACTERISTICS AND ARTIFACTS FOR DIVERSE RECORDING ELECTRODES

Konrad E. Schwarz[1], Stefan B. Strahl[1], Philipp Spitzer[1], Angelika Dierker[1], Florian Schwarze[1], Santiago L. Arauz[2], Marcus Atlas[2], Wolf-Dieter Baumgartner[2], Marco Caversaccio[2], Han DeMin[2], Javier Gavilán[2], Benoit Godey[2], Joachim Müller[2], Lorne Parnes[2], Christopher H. Raine[2], Gunesh Rajan[2], José Antonio Rivas[2], Henryk Skarzynski[2], Yuri Yanov[2], Patrick Zorowka[2], Paul van de Heyning[2]
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Introduction: *In a multi-center study (1) ECAPs of 141 subjects implanted with MED-EL standard and FLEX soft electrode arrays were investigated.*
Objective: *Electrically evoked compound action potentials (ECAP) and artifacts are analyzed towards physiologic and/or technical influences on basis of different recording electrodes inside the cochlea.*

Methods: *ECAP signals elicited by three stimulation electrodes (SE) located in the apical/middle/basal region using single biphasic pulses were analyzed. If neural responses within an Amplitude Growth Sequence (AGF) were visible ("success"), experts manually determined ECAP amplitudes. Thresholds respectively slopes were calculated using a sigmoidal fitting function.*
Results: *ECAP thresholds are found to be dependent only on stimulation electrodes (SE) and remain constant for different recording electrodes (RE). ECAP slopes are considerably smaller if the distance between SE and RE is increased (~2.5%/mm for SE in apex or base), most pronounced for SE in the middle region (~3.0%/mm). The "success" is roughly constant for all SE/RE pairs (>75%, highest at adjacent RE) and depends mainly on the maximal stimulation intensity of AGFs: >15 nC, "success" reaches 85% for single SE/RE pairs, and even 91% for fixed SE and varying RE. The so determined ECAP characteristics are further discussed with respect to magnitudes of artifacts.*
Conclusion: *The compound information "ECAP characteristics"/"artifact magnitude" as function of RE allows further insights in the individual cochlea physiology.*
1. Effects of Cochlear Stimulation on Electrically Evoked Compound Action Potentials. Van de Heyning, et al. Audiology & Neurotology Submitted September 1. 2015.

SPATIAL HEARING IN EAS LISTENERS

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Introduction: *Electroacoustically (EAS) stimulated listeners using a contralateral hearing aid (HA) are expected to utilise ITDs and localise low frequency sounds. The presence of HA on the contralateral side should also suffice with ILDs to localise broadband sounds. This is an ongoing study in EAS listeners investigating their sound localisation ability and the contribution of their hearing devices and i.e. cochlear implant (CI) and HAs to provide ITDs and ILDs for spatial hearing.*
Methods: *EAS listeners localise sounds of varying bandwidth originating from ±80 in azimuth in a dark soundproof room. In order to fully assess the benefit of EAS device four listening conditions are tested: EAS only, CI only, EAS plus contralateral HA and finally CI with a contralateral HA.*
Results: *Hearing devices perturb the binaural cues for a participant with good low frequency residual hearing. The localisation response for the same participant is best when all the devices are turned off.*
Discussion: *Balancing the gain of HA and electrical current input of CI may improve sound localisation. Independent functioning of HA son both sides with individualistic gain and compression settings might distort the ITDs needed for localising low frequency sounds.*

CONNEXINS AND KIR2.1 ION CHANNELS MODULATED IN HEARING LOSS PATIENTS BEFORE COCHLEAR IMPLANTATION

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Background: *Gap junctions are accountable to orchestrate the harmonic cell-cell connection where connexins have responsibility transporting ions and small molecules in the cochlea. The Kir2.1 ion channels have a role assuring the background currents in cells. Kir2.1 channels are known to cause hearing loss in Andersen-Tawil syndrome. However we have a modest knowledge on the impact of the altered gap-junctions in the inner ear in testing the hearing loss patients; and the level of connexins in the blood cells.*
Aim and methods: *In this study the hearing loss of patients was measured with distortion otoacoustic emission method (DPOAE) and tympanometry. Furthermore the expression of connexins and Kir2.1 ion channels were compared between patients with different age in cochlear implant users.*
Results: *Normal Eustachian tube function was detected in patients. As the middle ear ventilation found to be normal further objective measurements could be performed, thus these patients were included. The patterns of expressed Cx26 and Cx43 were changed in cochlear implant users. In cochlear implant candidates the outer hair cell function was diminished, as part of the inner ear lesion, leading to complete hearing loss. In the pathological groups from mild to moderate/severe outer hair cell dysfunction could be detected, which could be explained by co-morbidity (i.e. hypertension), tinnitus and age or noise exposure in the case history. These results suggest that the physiologically active connexins are crucial to facilitate the flux and recycling of potassium ions from intracellular space between two plasma membranes to maintain the normal hearing and the altered gap-junction exhibits distinct signalling mechanism.*
This work was supported by TAMOP-4.2.2.A-11/1/KNOV-2012-0052 and TAMOP-4.2.2.A-11/1/KONV-2012-0035.

AUDITORY EVOKED RESPONSES TO PITCH MATCHED STIMULI IN UNILATERAL COCHLEAR IMPLANT USERS WITH RESIDUAL HEARING IN THE NON-IMPLANTED EAR

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Background: *The existence of unilateral cochlear implant (CI) users with residual hearing in the non-implanted ear permits the evaluation of electroacoustic pitch matching across ears to better establish the perceptual correlates of each stimulating intracochlear electrode.*
Objective: *The overall goal of this study was to identify an objective physiological correlate of electroacoustic pitch matching in unilaterally implanted CI users with residual hearing in the non-implanted ear.*
Method: *This study presents interleaved electrical and acoustic stimuli that were either matched or mismatched in pitch and continuously alternates them across ears. 10 CI users were asked to adjust the frequency of an acoustic tone in the non-implanted ear to match the pitch percept elicited by a single intracochlear electrode stimulation; six repetitions for each electrode. Auditory Evoked Potentials (AEP)were obtained in response to an electrode stimulation and acoustic tones. One of these tones was pitch-matched to the electrode and the other tones were not. AEP were also obtainedfrom 10 normal hearing (NH) listeners with a 500 Hz acoustic tone replaced electrical stimulation.*
Results: *CI users indicated that N1 latency decreases when the acoustic frequency of the tone presented in the non-implanted ear increases. There was a further shortening of N1 latency in the pitch matched condition. These two patterns were also found in NH listeners.*
Conclusion: *Result indicate the potential utility of N1 latency as an index of pitch matching in both normal hearing listeners and cochlear implant users, and help in interpreting the behavioral result.*
(Supported by grantsK25-DC010834; PI: Tan, PSC-CUNY Program in Speech-Language-Hearing Sciences, Graduate Center of CUNY; PI:Martin, and R01-DC03937; PI: Svirsky).

A COMPARISON OF EABR AND NRI RECORDINGS IN CI USERS

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In our study the correlation of results obtained in EABRs registration and Express-NRI ECAPs was investigated. ECAPs and EABRs were parameterized with Growth AP on target electrodes 3, 7, 11 and 15. Corresponding stimulation generated simultaneously an ECAP and EABR (Van-den-Abbeele et al., 2014). Spread-of-excitation (SoE) with variable maskers were measured at an attenuation of 60% to characterize neural stimulation pattern delivered by a particular electrode contact. Electrode contact integrity was controlled by impedances that were systematically measured at each session. These single sessionof objective measurements were conducted on a mixture of pediatric and adult patients post-operatively. For each target electrode contact, correlation between EABR, ECAP threshold and behavioral dynamic range between T and M-threshold was investigated. Channel interaction was assessed by SoE. Combination of these Objective: measures resulted in an overall estimate of electrode-to-nerve interface quality and the ability of each contact to deliver focused stimulation. Relevance of these measures as a tool for Objective: prediction of CI programming parameters was then evaluated by comparison to speech intelligibility scores (in adults) and speech therapist's reports (in children).

In a follow-up stage, recommendations for programming will be based on objective measures gathered with the Volta™ objective measures software. These recommendations will be addressed to the centres responsible for long-term programming and (re)habilitation and applied initially to all subjects to produce a Volta-based program (V-program). Standard and V-programs then will be compared. The assessment of post-implant performance progress will be investigated after 12 months of cochlear implant use.

CORTICAL AUDITORY EVOKED POTENTIALS IN PATIENTS WITH COCHLEAR IMPLANTS

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Cortical auditory evoked potentials (CAEPs) can be recorded in infants and adults and provide evidence for speech detection at the cortical level. The validity of this technique as a tool of cochlear implant evaluation needs, however, to be investigated. The aim of this study was to evaluate the clinical usefulness and effectiveness of CAEP assessment in patients with cochlear implants.
36 patients wearing cochlear implants aged from 5 to 39 years were included in the study. CAEPs were registered with the use of the HEARLab System (Frye Electronics, OR, USA). The stimulus set comprised 3 specific tokens /m/, /g/ and /t/ with dominant power in the bands 200-500 Hz, 800-1600 Hz and 2000-8000 Hz and lengths of 30, 21 and 30 ms, respectively, presented at 55, 65 and 75 dB SPL. The present study examined the relationship between the presence/absence of CAEPs to speech stimuli and presence/absence of artifacts adversely affecting the CAEP waveforms.
The consistent existence of CAEPs over different stimulation levels (55, 65, 75 dB SPL) was shown in most subjects. The sensitivities across the types of stimuli were equal for /m/-76.3%, /g/-76.2% and /t/-70.5%. These values decreased to 62.7%, 59.4% and 53.6% when taking into account the presence of CI artifacts, which prevent confirming or denying CAEP presence. These results could be explained by poor speech discrimination in some CI users. Additional factors such as speech stimuli length possibly not suitable for CI users, audibility, effects of residual noise on the recordings etc. also should be considered.

EFFECT OF DIFFERENT COCHLEA ELECTRODE TYPES AND POSTINSERTIONAL FACTORS ON THE INTRACOCHLEAR PRESSURE

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Introduction: *The indication criteria for cochlear implantation have changed over the past decades to patients with residual hearing. To preserve residual hearing, the electrode design has been refined and an atraumatic insertion of the cochlear electrode has become one aspect of cochlear implant research.*
Objective: *The aim of our study was to observe intracochlear pressure changes due to different cochlea implant electrodes and postinsertional factors in a cochlear model.*
Methods: *The experiments were performed in an artificial cochlear model. A micro fibre pressure sensor was placed in the helicotrema area to monitor pressure changes. We compared 4 different electrode types (Advanced Bionics IJ, Helix, HFMS and LW 23) in terms of insertion speed, insertion time, tip size effects, electrode concept and electrode volume effects by means of hydostatic pressure, peak frequency and peak amplitudes. Additionally electrode sealing and cable spring forces were evaluated.*
Results: *We observed significant effects of electrode volume, electrode tip size, electrode insertion technique (lateral wall vs. midmodiolar) on hydostatic pressure, peak frequency and pressure amplitudes. Sealing technique and cable spring force can badly affect ICP.*
Conclusion: *In our model experiments electrodes characteristics have a significant influence on the intracochlear pressure changes in terms of mean maximum value, frequency and amplitude of peaks. Recommendations on sealing and cable packing to minimize ICP can be given.*

MRI BASED ESTIMATION OF SCALAR COCHLEAR IMPLANT ELECTRODE POSITION

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Introduction: *The scalar postion of the cochlear implant electrode is of high importance for the clinical outcome after CI surgery. Common techniques to evaluate the intracochlear electrode position include ionized radiation by MSCT, DVT or flat panel tomography. Recent advantages in the knowledge about handling MRI artifacts in cochlear implantees led to the assumption that an estimation of the intracochlear electrode position could be possible.*
Objective: *The aim of the study was to evaluate the assessment of the ipsilaterally scalar position of cochlear implant electrodes by MRI sequences at 1.5 T.*
Methods: *In a retrospective study we evaluated in 8 implantees with the postoperative need for an MRI scan the intrascalar electrode position in an axial position with a T2 weighted sequence at 1.5 T. We compared the evaluated intracochlear position with the routinely postoperative performed flat panel tomographiy and intraoperative NRT- ratio observed position.*
Results: *In all cases the MRT estimated scalar position corresponded with flat panel tomography and NRT-ratio estimated position. In six cases a scala tympani position was observed. In two cases a scalar change from scala tympani to scala vestibuli was found.*
Conclusion: *An estimation of the intracochlear position of cochlear implant electrodes by MRI is possible.*

CORTICAL EVOKED RESPONSES IN PATIENTS WITH BILATERAL COCHLEAR IMPLANTS

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Introduction: *Nowadays in parallel with the spreading of cochlear implants (CI) the number of implantees increases exponentially around the world. Depending on the time since implantation in patients fitted with these hearing assistive devices varying degree and speed of speech intelligibility improvement can be experienced.*
Objectives: The aim of our study was to determine the applicability of HEARLAb system through the assessment of cortical evoked responses in unilaterally and bilaterally fitted cochlear implantees.
Materials & methods: *In the first phase of the study we compared the cortical evoked responses of a patient with CI to a reference subject's values and the previously determined standard parameters set up with the HEARLab device. Thereafter we investigated the function of time has elapsed since implantation in bilaterally fitted 12 patients' evoked response parameters.*
Results: *The waves of the PI-N1-P2 complex, observed for the first time examined patient were reproducible and showed no significant deviation from the previous standard values. Evoked potentials were clearly detectable in patients with bilaterally fitted CI. Wave latencies were fallen within data ranges published in the literature. Our results demonstrate the strong correlation between the evoked potential parameters and the elapsed time after implantation.*
Conclusion: *Our HEARLab measurements prove that it is a clinically useful device in patients fitted with CI.*

DETERMINING FREE FIELD DETECTION THRESHOLDS IN COCHLEAR IMPLANT USERS USING A CLINICAL SINGLE-CHANNEL CORTICAL AUDITORY EVOKED POTENTIAL RECORDING DEVICE

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Introduction: *Cortical auditory evoked potentials (CAEPs) are used as an objective electrophysiological measure to clinically evaluate aiding in hearing-impaired individuals. However, the clinical application of CAEPs to cochlear implants (CIs) is in some cases impeded by the presence of an electrical artefact.*
Objective: *The aim of this study is to evaluate whether a clinical single-channel CAEP recording system can be modified for testing with CI users in the free field to determine their aided thresholds.*
Patients & methods: *Long (400 ms) narrowband noise stimuli (each 2 octaves wide starting from 125 Hz) were used to record CAEPs in 10 adult Cochlear CI users at 5 different levels ranging from 35 to 75 dB SPL in the free field through a loudspeaker at 0 degrees azimuth. Using recently developed artefact removal techniques in the literature (1), it was evaluated whether CI artefacts could be reduced further. An electrophysiological detection threshold was derived based on the CAEPs that were evoked at different presentation levels, and behavioral detection thresholds were determined for the same stimuli.*
Results: *Results will be presented that indicate whether longer stimuli are more suitable to reduce artefacts. By comparing the electrophysiological thresholds with behavioral thresholds obtained for the same stimuli, the accuracy of CAEP thresholds to predict behavioral thresholds will be assessed.*

Conclusion: *This project will form a preliminary step towards threshold estimation on directly stimulated CI electrodes, aiding with the objective fitting of these devices in the clinic.*

1. McLaughlin M, et al. Hear Res 2013; 302: 84–95.

HOW STEADY IS THE AUDITORY STEADY-STATE RESPONSE?

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Auditory steady-state responses (ASSRs) are auditory evoked potentials used in clinical practice and research for frequency-specific objective hearing assessments. Typically, the electroencephalogram is recorded for 2-5 minutes while presenting a long-duration modulated auditory stimulus. The auditory steady-state response amplitude is then estimated in the frequency domain, assuming that the ASSR amplitude remains stable over time.

However, it is unclear how stable the amplitude really is over time. We recently showed thatstimuli typically used for ASSR measurements can yield loudness adaptation, which is a decrease in loudness judgment over time. The aim of this study was to investigate the behavior of the ASSR amplitude over time, using stimuli that are known to cause loudness adaptation perceptually. The electroencephalogram was recorded from 64 scalp electrodes in 15 normal-hearing participants. During each recording of 92.16 s, a 40 Hz mixed-modulated sinusoid was presented at 30 dB sensation level with a carrier frequency of 500 or 2000 Hz. For each participant, 40 repetitions of each stimulus condition were consecutively recorded. Each recording was divided into overlapping window sizes of 20.48s at intervals of 5.12 s.

Due to the 40 repetitions of each stimulus condition, the amplitude of each window could be estimated with sufficient noise reduction by averaging. In addition, the results of individual recordings were compared using a novel type of analysis. We will present an analysis of the stability of the ASSR amplitude over time based on the two methods and compare the results with behaviourally measured loudness adaptation.

TONE DECAY IN COCHLEAR IMPLANT RECIPIENTS

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Introduction: *The variability in speech perception between cochlear implant (CI)recipientsis thought to partly result from variability in degeneration of the auditory nerve. In a substantially degenerated condition, the nerve response to a steady stimulus might decrease rapidly, resulting in tone decay, i.e., reduction of loudness towards 'no-percept'.*

Objective: *We examined whether speech perception can be related to tone decay in CI recipients.*

Methods: *Seven high and three poor performing CI recipients underwent tone decay measurements during two sessions. We electrically stimulated on a basal, central or apical electrode directly. Stimulation lasted for 60 s and consisted of 700 ms time frames with varying pulse rates (250, 1000, and 5000 pps) and duty cycles (10 to 100%). Duration of 'sound' perception was measured as a function of current level.*

Results: *Poor performers did not differ from high performers with respect to threshold of sound perception in any of the stimulation conditions. As for tone decay, two of the three poor performing subjects showed much stronger tone decay at a pulse rate of 5000 pps with a duty cycle of 100%, compared to the good performers.*

Conclusion: *We conclude that loudness adaptation can be measured with an electric tone decay test using a high pulse rate. The tone decay recorded in two CI recipients might be related to severe degeneration of the nerve which presumably plays a role in the poor speech perception in those individuals.*

THE EFFECT OF COCHLEAR IMPLANTATION ON TINNITUS IN ADULTS WITH SINGLE-SIDED DEAFNESS: A SYSTEMATIC REVIEW

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Introduction: *Tinnitus is a spontaneous, disagreeable auditory sensation. It affects daily living and quality of life. Tinnitus can occur in patients with normal hearing, but most often it appears together with hearing loss, including single-sided deafness (SSD). The exact pathophysiology remains unknown. However it appears to be at the cochlear level since a cochlear implant (CI) has a positive effect on tinnitus.*

Objective: *The aim of this systematic review is to determine the effect of cochlear implantation on tinnitus in adults with single sided deafness.*

Method: *Literature was searched in the databases Medline, Embase and Cochrane, using the terms tinnitus, cochlear implant(s) and their synonyms. Only prospective cohort studies were included with adult patients who received their first CI for SSD and tinnitus. The methodological quality of the studies was independently rated using Critical Appraisal Skills Programme (CASP) lists for cohort studies.*

Results: *Eight articles were included and critically assessed. Three studies were considered of good quality, 4 of adequate quality and 1 study was insufficient. All studies reported a positive effect of CI stimulation on tinnitus, either complete suppression or at least reduction of tinnitus.*

Conclusion: *Cochlear implantation can be an appropriate treatment for patients with SSD and tinnitus. Activation of the CI has a suppressive effect on tinnitus complaints, or at least reduces tinnitus. Results differ in degree and situation and can associate with different factors. Less tinnitus lowers stress and improves quality of life. In case of SSD and tinnitus CI is worth considering.*

AUDIOVISUAL SPEECH RECOGNITION IN COCHLEAR IMPLANT USERS MEASURED WITH FUNCTIONAL NEAR-INFRARED SPECTROSCOPY

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Introduction: *Recently, functional near-infrared spectroscopy (fNIRS) was successfully used as a neuroimaging tool to objectively assess audiovisual brain activity from adult cochlear implant (CI) users. Here, we address limitations as noted in our previous study (1).*

Objective:

1. To construct and assess a corpus of audio-visual samples based on the Dutch matrix test.

2. To determine auditory (speech listening), visual (speech/lip reading) and audiovisual speech recognition in noise for normal-hearing and CI users.

3. To relate behavioral performance to temporal cortex activation measured by 48-channel fNIRS.

Methods: *Audiovisual material comprising 180 Dutch sentences has been recorded and edited. Psychometric speech recognition functions for 10 normal-hearing subjects and 10 postlingually deaf CI users were determined for speech listening in noise and speech reading with blur. The signal-to-noise ratios eliciting 25, 50 and 75% performance in the unisensory conditions were used to assess audiovisual performance and temporal cortex activation.*

Results: *Normal-hearing speech listening recognition yieldedhigh-performance thresholds (–12 dB) compared to an earlier auditory-only corpus (2). Speech reading performance was highly variable (without blur, 20-79%). Performance variance (between individuals, groups, modalities and noise levels) is reflected in fNIRS activation of cortical regions. Both audiovisual behavioral performance and audiovisual activation of temporal cortex can be explained by probabilistic combination (i.e. minimal, additive integration, no cross-modal reorganization).*

Conclusion: *Speech recognition performance and fNIRS cortical activation are correlated. Audiovisual integration is minimal. CI users are not better visual integrators.*

1. LPH van de Rijt, et al. 2016. doi:10.3389/fnhum.2016.00048

2. Houben R, et al. 2014. doi:10.3109/14992027.2014.920111

BIMODAL PROCESSING WITH AEP RECORDINGS, PART I: EVIDENCE FROM THE AUDITORY BRAINSTEM RESPONSE

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Introduction: *Continuous advances in cochlear implant (CI) technology have led to a relaxation of the implantation criteria. Hence, an increasing amount of CI-users combine electrical and acoustical hearing in opposite ears. To date, it is unclear how the central auditory system processes binaurally presented electrical and acoustical*

signals. This study explores the utility of the auditory brainstem response (ABR) to assess brainstem processing of bimodal stimulation.
Methods: *Ten CI-users with substantial contralateral residual hearing volunteered in the study. The non-implanted ear was stimulated acoustically, whereas the implanted ear was stimulated acoustically. Before starting the ABR acquisition, the electrical and acoustical stimulation was pitch and loudness balanced. Subsequently, ABRs were recorded to monaural acoustical, monaural electrical, and bimodal stimulation.*
Results: *Electrical ABRs were found in all subjects in both the monaural and bimodal condition. Acoustical ABRs were obtained in three subjects. The presence of monaural acoustical ABRs depends both on the degree and configuration of the contralateral residual hearing. The bimodal ABR of each of these three subjects showed a different, but reproducible, morphology.*
Conclusion: *Although acoustical ABRs were not always present, these preliminary data show that it is feasible to obtain brainstem responses to bimodal electro-acoustic stimulation.*

BIMODAL PROCESSING WITH AEP RECORDINGS, PART I: EVIDENCE FROM THE COGNITIVE P300 AUDITORY EVENT-RELATED POTENTIAL

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Introduction: *Continuous advances in cochlear implant (CI) technology have led to a relaxation of the implantation criteria. Hence, an increasing amount of CI-users combine electrical and acoustical hearing in opposite ears. To date, it is unclear how the central auditory system processes binaurally presented electrical and acoustical signals. This study explores the utility of cognitive P300 auditory event-related potential to assess bimodal benefit.*
Methods: *Five bimodal were included in the study. All participants had ipsilateral residual hearing, which was amplified by a conventional hearing aid. None of the participants had ipsilateral residual hearing. The cognitive P300 response was elicited using an oddball paradigm with a 500 Hz tone-burst as standard and a 250 Hz tone-burst as deviant stimulus. P300s were recorded in response to CI-only and bimodal stimulation.*
Results: *In four out of five subjects, bimodal stimulation elicited better P300 than CI-only stimulation. In these subjects, latencies were shorter and amplitudes were larger in the bimodal condition. The results on P300 measures were in agreement with their behavioral discrimination abilities.*
Conclusion: *These preliminary electrophysiological data reveal that bimodal condition elicited better cognitive P300 responses than CI-only condition. Bimodal listeners use various cues to perform cortical discrimination tasks.*

SIMULTANEOUS RECORDING OF ECAPS AND EABRS USING THE ADVANCED BIONICS RSPOMTM AND THE ECHODIA ELIOSTM SYSTEM

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Objective: *Compare ECAP and EABR thresholds obtained simultaneously during cochlear implant surgery.*
Background: *Electrically Evoked Compound Action Potentials (ECAPs) are commonly used in clinical routine to assess peripheral encoding of electrical stimulation and to provide some degree of assistance in cochlear implant programming. It is expected that taking more central processing into account could help improve the so far moderate correlations between ECAP and behavioral thresholds. In addition, better understanding of auditory nerve activity could be gained by comparing intracochlear ECAP signal to scalp-recorded EABR wave I.*
Methods: *Twenty-six pediatric subjects were included in the study. ECAPs were measured intraoperatively with RspOM™ using 5 points Growth-AP with 75 µs biphasic pulses. EABRs were measured in parallel with the Elios™ ABR setup operating at a 90dB gain with a 32 kHz sampling frequency. No filtering was applied before 200 µs post-stimulus to prevent filtering rebound from contaminating the expected neural response. ECAP measurements and Wave I, III and V growth functions will be compared in terms of latencies, slopes and thresholds.*
Results: *EABRs could be reliably recorded in 80% of the subjects included so far. When measurable, EABRs wave III and V were linearly fit, as NRI. Obtained tNRI were at an average of 146 CU, tIII at 84 CU and tV at 172. Overall, significant, but weak correlation was obtained between tNRI and tIII or tV.*
Conclusion: *EABRs were successfully recorded in combination with ECAPs, absence of correlation between NRI and EABR show that they provide complementary information. This promises increased relevance to assist in implant programming. This combined functionality is now available in VOLTA.*

COCHLEAR IMPLANT IN PRELINGUALLY DEAFENED ADOLESCENTS: ROAD BLOCKS

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Introduction: *Cochlear implantation (CI) has been considered as the best accepted treatment option for individuals 12 months or older who have bilateral severe to profound SNHL. Early age of cochlear implantation relates to successful Results; however CI has also showed improvement in older prelingual children and adolescent.*
Objective: *To find out factors influencing use, partial and non use of cochlear implants (CIs) in prelingual adolescent patients implanted in adolescence in comparison to who were implanted in childhood.*
Method: *Two groups participated in the present study. Group 1 included 20 adolescent individuals (the age range of 11-18 years) who got cochlear implantation during their adolescence years and duration post implant is at least 2 years. Group 2 included 20 adolescent individuals (age range of 11-18 years) who underwent cochlear implantation during childhood that is before 5 year of age. An informal questionnaire was administered on adolescent and their family members regarding their use of cochlear implant in different situation, usefulness and difficulties faced etc. speech language and hearing performances were also evaluated.*
Results and discussion: *Results showed that many parameters such as previous use of hearing aid, family support and behavioural problems etc were the factors mainly influencing the use and non use of cochlear implants in adolescent individuals. Further, in Indian scenario factor that played a significant role was their finances or ability to maintain their devices.*
Conclusion: *Individuals who get cochlear implantation done in their adolescence years also get benefits. However many factors related to motivation, family & clinical support, money needs to be addressed appropriately for utilizing benefits from cochlear implants to the maximum.*

THE ACOUSTIC CHANGE COMPLEX AND ITS RELATION TO SPEECH PERCEPTION IN NOISE IN SENSORINEURAL HEARING IMPAIRMENT

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Introduction: *The acoustic change complex (ACC) is acortical potentialevoked by a change in an ongoing sound, e.g. a frequency change. Since frequency changes are a fundamental part in speech sounds, the ACC is considered as an objective measure which may be related to speech perception.*
Objective: *To investigate the relationsbetween the ACC elicited by frequency changes and psychophysical outcomes as frequency discrimination and speech reception in noise.*
Methods: *In 10 patients with sensorineural hearing loss and 9 normal hearing controls we recorded ACCsin response to frequency changes and obtained psychophysical frequency discrimination thresholds and speech reception thresholdsin noise.*
Results: *The ACCs of the hearing impaired group showed higher thresholds, smaller N1-P2amplitudes and longer N1 latencies compared to the normal-hearing controls. As expected, the hearing impaired group performed more poorly on the frequency discrimination and speech perception tasks than the normal-hearing controls. Unexpectedly, none of the ACC measures including thresholdwere correlated to frequency discrimination. However, interestingly, subjects with better speech perception results showed shorter ACC N1latencies.*
Conclusion: *The ACC thresholds are poor indicators for hearing performance. The suprathreshold ACC latency instead appeared to be an indicator for speech perception in noise, and thus may have value as an objective measure to assess hearing performance in hearing-impaired subjects.*

ELECTRICALLY EVOKED AUDITORY BRAINSTEM RESPONSES AND ACOUSTIC CHANGE COMPLEXES IN ADOLESCENTS WITH SEQUENTIAL BILATERAL COCHLEAR IMPLANTS

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Introduction: *In sequentially implanted bilateral deaf children, a prolonged inter-implant interval may have a negative effect on auditory performance with the second implant(CI2). This lowered performance with CI2 compared to the first implant(CI1) might occur due to compromised plasticity of the central auditory system, resulting from the period of unilateral auditory stimulation by CI1.*

Objective: *Comparing electrically evoked auditory brainstem responses (eABR) and electrically evoked acoustic change complexes (eACC) of the auditory cortex between CI2 and CI1 in adolescents with long inter-implant intervals.*

Methods: *In 8 bilateral adolescentCI users with long inter-implant intervals (median 11.6 years, range 4 to 15) eABRs and eACCs were obtained one year after implantation of CI2.*

Results: *The consonant vowel consonant(CVC) phoneme scores were significantly lower in CI2 (median 62%) compared to CI1 (median 93.5%). On the average, latencies of eABRwave III and wave V were longer for CI2 than for CI1(median 1.90 and 3.95 ms vs 1.88 and 3.55 ms respectively), however, these differences were not significant. The N1 and P2 latencies, and the N1-P2 amplitudes of the eACCs did not differ between CI2 and CI1.*

Conclusion: *Based on these preliminary results, the lower hearing performance with CI2 could not be associated with differences in latencies or amplitudes of eABRs and eACCs.*

CORTICAL NEURAL MANIFESTATIONS OF BINAURAL PROCESSING IN CHILDREN USING A COCHLEAR IMPLANT AND A CONTRALATERAL HEARING AID AND IN CHILDREN USING BILATERAL HEARING AIDS

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Background: *In normal hearing (NH) listeners binaural processing manifests in binaural interaction components (BICs) that occur along the auditory pathways and can be documented by means of evoked potentials. In the presence of bilateral hearing loss (HL) habilitation by means of two hearing devices is standard-of-care treatment. It is unknown, however, whether BICs occur in listeners using bilateral hearing aids (HA) and in those using a cochlear implant (CI) and a contralateral HA.*

Methods: *Auditory event-related potentials (AERPs) were recorded from children with:*
1) bilateral symmetrical moderate-severe HL that were using bilateral HAs,
2) bilateral progressive severe-profound HL using CI+HA, and compared to NH children. Participants performed oddball speech discrimination tasks presented in three listening conditions: monaural right/left, and binaural. BICS were derived by subtracting AERPs elicited in the binaural condition from the sum of AERPs elicited in the right/left conditions. sLORETA was utilized to estimate neural sources of AERPs and BICs.

Results: *BICs in the N1 and P3 time-frames were found in all NH listeners, in most children using bilateral HAs, and only in some children using CI+HA. Latencies of N1, P3, N1-BIC, P3-BIC were prolonged in children using bilateral HAs and CI+HA, compared to NH children. Interestingly, a late negative component (LNC) was evident in most bilateral HA and in CI+HA users whereas in NH children LNC was absent.*

Conclusion: *Data provide first-time evidence for the occurrence of cortical BICs in children using bilateral HAs and in some children using CI+HA, supporting binaural processing. AERP's and BIC's characteristics support differential binaural processing during perceptual and post-perceptual stages in hearing-impaired children compared to NH listeners.*

ASSESSING SPATIAL HEARING BY UTILIZING THE MISMATCH NEGATIVITY RESPONSE

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Introduction: *Hearing with two ears is superior over hearing with one ear especially in complex auditory environments since it provides access to binaural cues. However, listeners who suffer from a hearing loss display difficulties regarding auditory spatial hearing. Until today, it is a matter of debate to what degree hearing devices give access to binaural cues and whether listeners can integrate them into a coherent percept.*

Objective: *The main focus here is to use the mismatch negativity as an objective electrophysiological measure to assess automatic spatial discrimination that requires bilateral integration in patients with CI.*

Materials and methods: *In the present study, bilateral listening conditions have been compared with unilateral listening conditions where a one sided hearing loss was mimicked in a group with normal hearing. Listeners were seated in a free field. Within a classic passive oddball paradigm, acoustic stimuli were presented from four different fixed locations. Auditory evoked potentials were analyzed for the different conditions.*

Results: *All participants showed strong individual mismatch negativity responses in the bilateral condition. During unilateral listening, reduced or even absent MMN amplitudes were seen.*

Conclusion: *The mismatch negativity elicited by acoustic spatial deviations can be used as an objective measure to investigate spatial hearing, complementing or replacing behavioral methods for example in incompliant groups such as children with cochlear implants.*

ARTIFACT OR ENTRAINMENT? COHERENCE BETWEEN BRAIN ACTIVITY AND SPEECH IN EEG RECORDINGS WITH COCHLEAR IMPLANT USERS

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EEG studies with CI users suffer from the presence of electrical artifacts induced by the device. The transmission of natural speech through the CI induces artifacts to EEG recordings that reflect the amplitude modulations in speech, leading to an alignment between EEG and speech signal. For normal hearing (NH) listeners this sort of alignment, called neural entrainment, has been suggested to be foundational to speech processing.

A number of studies (e.g., Luo & Poeppel, Neuron 2007) suggest that entrainment of neural oscillations and the temporal amplitude modulations of speech reflect stages of decoding of acoustic features or linguistic parsing during speech perception. This study investigates the alignment between EEG signals recorded with CI users and natural sentences, to investigate how much of this alignment reflects brain signals engaged in speech processing. We compare the EEG signals of ten experienced CI users with their own devices, with ten normal hearing (NH) participants, recorded while listening to naturally spoken sentences.

Coherence between EEG recordings and the speech signal was found within the range of slow neural oscillations (2-18 Hz). Both groups of listeners showed a coherence peak around 4-8 Hz (theta) range, but the magnitude of coherence differed between groups and across cortical regions. The group differences were reduced on central electrodes, suggesting that the alignment may indeed reflect a step in speech processing and not only an artifact for CI users. We will discuss the sources of variability in coherence across participants, and the relation of coherence to speech comprehension tasks.

THE TIME COURSE OF TOP-DOWN PROCESSING DURING SPEECH PERCEPTION BY NORMAL HEARING AND CI USERS

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CI users need to re-learn to process speech. The ability to rely on top-down processes, such as integration of semantic information from the context can facilitate understanding. This paper focuses on listeners' ability to use semantic information to anticipate words within sentences when processing natural and CI simulating speech, as well as understanding speech by CI users. In an eye-tracking experiment we recorded listeners' gaze fixations as an online measure of lexical decision making. In addition, we recorded listeners' pupil dilation to capture mental effort involved in speech processing.
Participants' gaze fixations to pictures on a screen were recorded while listening to sentences containing target words (baby), which were either preceded or followed by disambiguating context (crawl). The display pictures contained the target (baby), a competitor word with phonologically similar onset (bay), a word that was semantically viable given the sentential context (worm given the context crawl), and an unrelated distractor.
The gaze fixations results for natural speech show a fast uptake of acoustic information and quick integration of sentential context. The course of pupil dilation shows that early semantic integration offers a release from effort involved in lexical decisions. Degradation of the signal leads to a delayed integration of semantic information. Processing degraded speech comes with increased effort due to the impoverished nature of the signal, and delayed integration of semantic information further constrains listeners' ability to compensate for inaudible information. We will discuss potential sources of individual variability in adaptation to degraded signals by CI users.

ELECTROPHYSIOLOGICAL MEASUREMENT OF PITCH PERCEPTION IN COCHLEAR IMPLANT (CI) USERS

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Pitch is one of the primary auditory percepts. Variation of pitch is associated with the perception of melodies. In CI users the transfer of spectral components and temporal fine structure is limited and the perception of pitch and timbre still difficult. Auditory pitch detection relies on cochlear and central regularity detection. There are two main concepts of pitch perception, the place code (tonotopy) and the time code (periodotopy). To investigate these components separately stimulus presentation in CI users are used. In this study it is investigated if CI users can percept pitch and if it is possible to measure this objectively. We examined iterated rippled noise (IRN) perception in normal hearinglisteners and CI users with their everyday fitting and a fitting with just one active electrode. In IRN white noise is delayed and added on its original. The frequency of the perceived pitch is determinedby the reciprocal of the delay time and its strength by the amount of addediterations. Difference limens for IRN iterations were determined psychoacoustically before measuring auditory evoked potentials with 32-channel EEG recordings. Pitch-onset-response (POR) was found for IRN in both groups. With increasing pitch strength the POR amplitude grows and the latency becomes shorter. Even when presenting the IRN on one single cochlear electrode a pitch perception is reported and in single subjects a POR can be measured.
Pitch perception in CI users can be evaluated objectively and could be used with non-cooperative patients for monitoring of ongoing audio-verbal therapy after CI surgery.

RECORDINGS OF ACOUSTIC EVOKED POTENTIALS DIRECTLY FROM THE DIFFERENT PLACES OF COCHLEA VIA INTRACOCHLEAR ELECTRODES IN COCHLEAR IMPLANTEES

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Introduction: *The latest developments in cochlear implants, electrodes and surgical techniques allowed for expansion of indication criteria in cochlear implants. Currently, it is possible to implant patients with Partial Deafness (PD), with normal hearing up to 1.5 kHz and with high frequency severe to profound sensorineural hearing loss with certain degree of hearing preservation after the cochlear implantation.*
Using an appropriate tools allows us to perform measurements that have never been obtained in human and further to improve our understanding of inner ear and hearing. For instance, to this date it was not possible to record acoustically evoked or acoustically and electrically evoked response directly from the cochlea.
Our pioneering work showed that recordings of acoustic evoked potentials directly from the different places of cochlea are possible using implant electrode.
Material and method: *50 implanted adults participated in this study. All of them use Med-El devices like Pulsar, Sonata, Concerto and Synchrony.*
The acoustical stimuli (250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz) were presented via inserts placed in the ear canal of the subject in implanted ear. The personal computer with Synergy system was used for controlling and providing acoustical stimulation. Near field responses were recorded from multichannel intracochlear electrode using MAX programming interface.
Results: *Responses for all frequencies were obtained for 37 of 50 patients.*
Conclusion: *Preliminary results, presented in this work, show possibility of acoustically evoked responses from the cochlea using multichannel electrode of cochlear implant. Study was supported by grant of National Science Centre (NCN) number DEC-2013/09/B/ST17/04213*

OBJECTIVES ASSESSMENT OF CP910/CP920 SOUND PROCESSOR USAGE FOR SSD CI RECIPIENTS VIA DATALOGGING

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Introduction: *In 2013 the Nucleus 6 CI sound processors, CP910 and CP920 were launched. The data logging capability is one important design feature of these processors. It provides audiologists with information about how the processor is used every day. Specifically it records the amount of time spent in different auditory environments, as well as the preprocessing programs and accessories used.*
Objective: *The aim of our investigation is to find out if processor usage is influenced by characteristics of the recipient group such as hearing loss and age. Recipient groups examined included unilateral CI recipients with single-side deafness (SSD), unilateral CI (UniCI) and bilateral CI (BilCI) recipients with bilateral sensorineural hearing loss (SNHL).*
Patients and methods: *The cohort examined via an observational study included 27 SSD CI recipients and 114 UniCI recipients using a CP910 or CP920, and 65 BilCI recipients using at leastone CP900 series sound processor. Recipients across subgroups were matched with regard to age at assessment. Sound processor usage data recorded such as time on air, and time spent in each of six auditory environments: "Quiet", "Speech", "Speech in Noise", "Noise", "Wind" and "Music" was extracted via acustomized analysis tool.*
Results: *On average, SSD CI recipients use their implant 35% of time, and UniCI and BilCI recpients for approximately 45% and 46% of time, respectively. Compared to UniCI and BilCI, SSD CI recipients are observed to be in "Speech in Noise" environments approximately 6% more often than other recipient user groups, while no difference is observed for "Music" and "Noise" environments. For all recipient groups, a trend is shown for an influence of age upon the time spent in "Quiet", which is increasing with increasing age.*
Conclusion: *SSD CI recipients display similar usage patterns for CP910/CP920 sound processors to those shown for UniCI and BilCI recipient groups. Clinically, based on device usage, the patient satisfaction with their implant(s) may be inferred. Consistency of use is found to be similar between all three recipient groups. Furthermore the information available through data logging can support counseling of the recipient on a case by case basis.*

DEVELOPING A NEW OBJECTIVE MEASURE TO QUANTIFY LISTENING EFFORT IN COCHLEAR IMPLANT USERS: A PILOT STUDY

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Assistive technology enables cochlear implant recipients' audiograms to improve to that of a mild hearing loss. Yet, this is not a perfect solution because even mild hearing loss leads to increased listening effort. Listening effort is a pertinent concern because it has been demonstrated to result in compromised speech processing and increased cognitive burden. Yet, listening effort remains unaddressed in all current clinical assessment. This research project created the first ever prototype of an objective measure of listening effort for cochlear implant users. This prototype was based on a novel dual task paradigm, whereby a primary task of auditory recall was simultaneously executed alongside a secondary task of visual recall, whereby secondary task performance was utilised as an index of listening effort. To validate the sensitivity and reliability of this new listening effort index, an already proven physiological correlate of listening effort was utilised:pupil dilation. In addition, a thorough assay of cognitive, executive, intellectual and hearing function was performed to remove any interfering variables. A pilot study of the prototype revealed that, whenfive adult normal hearing

controls listening to cochlear implant simulations and four adult cochlear implant users were tested, secondary recall performance was worse, and pupil dilation response greater in the cochlear implant user group compared to the normal hearing group, despite no significant differences in cognitive, executive and intellectual ability. Therefore, there are indications that
1) listening effort is being detected by this prototype and
2) listening effort is indeed detrimentally increased in cochlear implant users.

CHANGES IN THE TEMPORAL RESPONSE OF THE AUDITORY NERVE OVER TIME: RECOVERY FUNCTION AFTER 12 MONTHS OF COCHLEAR IMPLANT USE

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Introduction: *The recovery function (REC) recorded with the electrically evoked compound action potential (ECAP) measures the time that the auditory nerve needs to recover from a stimulus and exit the absolute refractory period to receive new stimulations. Continuous stimulation may improve nerve conductibility and nerve fibers recruitment.*
Objective: *To investigate the changes of the ECAP-REC after 12 months of CI use, and to evaluate its test-retest reliability.*
Methods: *Measurements of ECAP- RECwere obtained in five children, implanted with Nucleus CI24RE CA devices. ECAP-REC was measured using Custom Sound EP4.2 software in the defaultsetting. Measurements were performed in the intraoperative test and after 12 months at the electrode 11 in the medial portion of the cochlea. Test-retest reliability of the ECAP-REC was analyzed with tworepetitive measures at the 12-months session. The analyzed parameter from the REC function was tau, a relative refractory time of the auditory nerve fibers, referred as to the curviness parameter for the model function, at both intraoperative and postoperative sessions. Except for the current level, all stimulation parameters were similar, including the stimulation rate (80 Hz).*
Results: *Preliminary results showed a tendency to longer refractory timeafter continuous CI use. Nevertheless, this trend was not seen in all children. The test-retest reliability revealed the measurement is stable, with no statistical significant differences across repetitive measures (p-value p>0.005).*
Conclusion: *Since the refractory time of the auditory nerve fibers is stable, changes over timemay bea reflection of the continuous stimulation.*

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