8TH INTERNATIONAL SYMPOSIUM
on objective measures in auditory implants

October 15-18, 2014
Toronto, Ontario, Canada

Hilton Hotel Toronto

SYMPOSIUM ABSTRACTS

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Table of Contents

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Invited Speaker Abstracts

Invited Speaker Abstracts (in order of presentation)

Thursday, October 16, 2014

Discussion I: The Unique Ear

Genetic Testing for Deafness: Where we were, where we're going, and why we should get there

Dr. Richard Smith

Massively parallel sequencing (MPS) is revolutionizing human genetics and promises to be the harbinger of personalized medicine. In the treatment of deaf and hard-of-hearing persons, this technology has made comprehensive genetic testing possible and as a result, it has changed the clinical evaluation of these persons. The OtoSCOPE® platform, which we developed, uses targeted sequence capture (TSC) paired with MPS to sequence all exons of all genes involved in hearing loss simultaneously. To analyze OtoSCOPE®-generated data, we have developed two complementary tools. The first is a bioinformatics platform, which incorporates allele frequencies of deafness gene variations from multiple ethnically different control populations to facilitate variant calling, and the second is a machine-learning tool called AudioGene, which predicts the genotype from the phenotype and offers clinicians a new way to look at audiograms.

Using OtoSCOPE®, our overall diagnostic rate is ~40% but varies by clinical phenotype from 0% for persons with asymmetric hearing loss to ~60% for persons with bilateral autosomal recessive non-syndromic hearing loss. Each patient's OtoSCOPE® run generates on average 15-million mappable sequence reads. We typically sequence targeted bases to 1,601X depth-of-coverage and cover 98.2% of targeted bases at our variant calling threshold of 10X. To facilitate variant calling, we have established population-level frequencies of reported deafness-causing variants in 1,000 controls from six ethnic populations. We have also incorporated the analysis of copy number variations (CNVs) into our pipeline, an important feature since a CNV is implicated in ~20% of genetic diagnoses. This type of analysis will be integral to personalized genomic medicine and will be the foundation upon which gene-and-mutation-specific habilitations options are developed for the treatment of hearing loss. In addition, 'unsolved' OtoSCOPE® families represent a valuable resource for research focused on novel gene discovery.

Cochlear Nerve Disorders in Children: An evolving management paradigm

Dr. Craig Buchman

Cochlear nerve disorders can take the form of either a gross anatomic abnormality apparent on high-resolution imaging studies (i.e. cochlear nerve deficiency) or might only be revealed through careful functional assessment (i.e. auditory neuropathy spectrum disorder). The perceptual consequences for children with these conditions can also vary widely, requiring a flexible and escalating management scheme. While some children with cochlear nerve disorders require only limited intervention, others are better served with amplification, cochlear implantation (CI), or possibly auditory brainstem implantation (ABI). This talk will discuss this group of disorders and the evolving management paradigm based on a combination of imaging and objective measures.

Auditory Neuropathy Spectrum Disorder (ANSD) and Cochlear Implants: A shared problem of low information channel capacity

Dr. Robert Harrison

Patients with auditory neuropathy spectrum disorder (ANSD) and subjects with cochlear implant devices share the common problem of severe channel capacity reduction. A major etiology of auditory neuropathy spectrum disorder (ANSD) is chronic cochlear hypoxia. Animal models (Harrison 1998) and human

studies (Amatuzzi et al. 2001) have shown that this causes extensive but sub-total damage to inner haircells and the synapses with spiral ganglion neurons. The result is a significant reduction in channel capacity at the cochlear nerve level, and beyond. This condition helps to explain some of the symptoms of the disorder, in particular a lack of correlation between behavioural thresholds and both ABR characteristics (e.g. Starr et al. 1996) and complex sound processing (e.g. Zeng et al 1999). Thus hearing thresholds can "normal" with relatively few channels, but large numbers of active neurons are required for generation of ABR signals. Similarly complex sound analysis is best achieved if information is carried in large numbers of channels. Cochlear implant devices, because of the limitations on electrode number and the associated speech processing strategies, provide patients with information via a low channel capacity system. In this sense, a person with cochlear implants can be considered to have a version of ANSD. This discussion will further explore the analogy between subjects with ANSD and cochlear implantees, and the consequences of low information channel capacity. Are they really similar? Can we be more informed about CI performance and habilitation strategies from our knowledge about patients with ANSD?

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Discussion II: The Unique Choice

Crossmodal Reorganization and Prognosis of Cochlear Implant Outcome in Postlingual Deaf Patients

Dr. Pascal Barone

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The cochlear implant allows profoundly postlingual deaf patients to recover speech intelligibility through long-term adaptive processes to build coherent percepts from the coarse information delivered by the implant. However, the temporal evolution of recovery can greatly varies across subject during the first year post-implantation. Because the strategy adapted by CI users for speech comprehension is linked to the cortical crossmodal plasticity that affects the pattern of brain activity during speech processing, our approach was based on searching for brain regions whom the level activity at time of implantation is correlated with the level of auditory recovery several months later. We used Pet scan brain imaging to analysed the correlation between brain activity at the moment of implantation and auditory word perception scores 6 months after the implantation. Correlations were observed in a set of areas outside the auditory cortex with the highest correlation in the right occipital cortex involved in visual processing. Other correlated areas included the posterior temporal cortex known for audiovisual integration and the left inferior frontal area involved in cognitive function including speech processing. These results show that the initial high activity of the visual cortex provides the best potential to favour auditory recuperation. In a more general perspective, the influence of the visual cortex on the efficiency of the purely auditory speech perception shown in this study suggests the existence of some neural facilitation mechanisms that link both sensory modalities so that a better functional level of one modality leads to the better performance of the other. Such cooperation between different sensory modalities may be a reflection of the multisensory nature of speech processing, it supports the large set of data demonstrating an important role of visual input for speech comprehension in cochlear implanted postlingual deaf patients.

PET Functional Studies in Patients with Asymmetric Hearing Loss

Dr. Manuel Manrique

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The study of regional cerebral metabolism by positron emission tomography (PET) can be applied to the primary and associative auditory cortices, providing important information about normal hearing, hearing loss, and the neuroplasticity processes of the auditory system.

We have used isotopes H2 15O and 18F-FDG to assess basal and activation metabolic status of the auditory pathway, under different protocols of study, in an attempt to elucidate the optimum set for an effective evaluation. Auditory stimulation is better with speech, followed by white noise, and clicks. PET-scan studies offer vital information concerning the time process for hearing restoration in cases of severe-profound hearing impairment. Additionally, this exploration offers valuable data in order to take decisions in patients with long-lasting unilateral profound hearing loss combined with the contralateral ear having some functional hearing. These patients are quite difficult to counsel in the process of selection for cochlear implantation, as there is a lack of functional information on neural plasticity. This exploration technique helps us to settle the question of a possible indication for a cochlear implant in the deaf ear. The signs that suggest a good prognosis to implant in the profound ear are:

- Basal situation, without acoustic stimulation should show hypometabolism in the contralateral auditory cortex to the deaf ear. The extent and amount of hypometabolism reveals whether or not those regions that are critical for speech perception remain available for auditory language. Thus, reduced metabolism in temporal cortices of deaf subjects indicates a latent susceptibility to auditory restoration via a CI.
- After acoustic stimulation, the increment of metabolism in both cortices. There is a significant correlation between cortical activation in the primary auditory cortices and speech perception outcomes.

Objective Measures of Residual Hearing: Use in pre-CI candidacy trials

Dr. Susan Scollie

Modern signal processing in hearing aids allows better access to a broad bandwidth of sounds across a greater output range than ever before. How can we account for these changes in hearing aid fittings, especially those that serve as amplification trials for determining candidacy for cochlear implants? This presentation will review the key hallmarks of high-quality fittings and specific objective strategies that introduce rigour into the fitting process. Case studies and presentation of experimental data will illustrate the factors of sensation level of phonemes and recent outcomes with modern hearing aid processing in older children. Specifically, studies of phoneme-specific audibility with frequency lowering signal processing will be reviewed to illustrate what is possible with today's processors. Selected procedures for assessing hearing aid outcome (and their limitations) will be reviewed, with a view to future directions in research and future clinical protocols.

Single-Sided Deafness Disrupts Sensitivity to Binaural Cues

Dr. Andrej Kral

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Previous studies have shown that early single-sided deafness leads to a reorganization of aural preference in the brain (Kral et al., 2013, Brain; Kral et al., 2013, Front Syst Neurosci). Here we investigated sensitivity to binaural cues in the auditory cortex and compared binaural and monaural properties of neurons with cochlear implant stimulation in adult normal hearing cats (HCs), congenitally

deaf cats (CDCs) born deaf on both ears, and cats born with unilateral deafness but normal hearing on the other ear (uCDCs). In CDCs the monaural response thresholds, dynamic ranges and spontaneous activity were significantly reduced compared to HCs. There were fewer excitatory-excitatory (EE) responses and more 0E responses, but fewer binaural facilitation in CDCs. The highest spontaneous firing rate was found in uCDCs, followed by HCs and CDCs. uCDCs showed weaker responses to the deaf ear compared to the hearing ear. The monaural and binaural responsiveness depended on the relation of the recorded cortex and the hearing ear in uCDCs. The cortex ipsilateral to the hearing ear reorganized extensively, with more EE and less E0 responses. The cortex contralateral to the hearing ear demonstrated more E0 responses and more suppressive interactions. Facilitatory binaural interactions were similarly reduced in CDCs and uCDCs. ITD sensitive units were rare in uCDCs and mostly observed in the contralateral cortex. The ipsilateral cortex had more flat or non-classified ITD responses. In total, unilateral deafness prevented nonspecific deficits in responsiveness, but reorganized the hemispheres differently, with more extensive reorganizations at the cortex ipsilateral to the hearing ear. Finally, binaural interactions and ITD sensitivity were extensively reduced in unilateral deafness. These results demonstrate significant loss of binaural hearing following single-sided deafness and a hemisphere-specific reorganization as a consequence of the adaptation to single-sided deafness.

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Discussion III: The Unique Implant

Physiological Measures of Response to Acoustic, Electric and Combined Stimulation in Cochlear Implant Users

Dr. Carolyn Brown and Dr. Paul Abbas

Traditional cochlear implants bypass the normal transduction process in the cochlea and directly stimulate the auditory nerve. Many traditional cochlear implant users enjoy high levels of speech understanding and their success has led to changes in candidacy criteria. In fact, today, many individuals present for cochlear implant surgery with significant amounts of low frequency acoustic hearing and surgeons have begun to experiment with less invasive surgical approaches and novel electrode arrays that have been shown to help make preservation of acoustic hearing post operatively possible. Additionally, research has shown that it is possible for individuals to combine information presented acoustically and electrically within the same ear. This report explores the use of physiological measures to help us better understand how cochlear implant users are able to combine acoustic and electrical hearing and with the expectation that these findings will help guide future developments in electrode design and signal processing.

Animal data has shown that it is possible to electrically stimulate residual auditory hair cells directly (electrophonic responses) and provides evidence of interaction between acoustic and electric stimulation in primary auditory neurons. Data from human cochlear implant users shows it is possible to use either electrical or acoustic stimuli to record neural and/or hair cell responses from an intracochlear electrode. These peripheral measures can be used to monitor hearing loss after cochlear implantation, to determine the source of electrical responses, but also to evaluate interactions between acoustic and electrical stimulation in peripheral neurons. Cortical responses, however, can complement peripheral measures in a number of ways. Most importantly, they provide a window to higher order processing and they allow for the use of more spectrally and/or temporally complex stimuli such as speech or music. We have also been able to use cortical responses to assess the ability of individual cochlear implant users to combine acoustic and electric hearing and have recently begun a series of experiments where we use cortical responses to document the effects of auditory training.

This presentation will summarize data collected in our lab from cochlear implant users to both acoustic and electrical stimulation. Applications of these techniques to clinical practice and the implications for future work will be discussed.

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Delayed Loss of Acoustic Thresholds Following Cochlear Implantation – Clinical and Experimental Studies

Dr. Stephen O'Leary

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Background: Hearing loss that occurs months to years after otherwise successful hearing-preservation cochlear implantation (delayed hearing loss) occurs in approximately a third of patients, and can compromise the functional utility of the residual hearing. The cause(s) of delay hearing loss are not known. Here we examine in detail audiometric data followed for at least 12 months after cochlear implant (CI) surgery from Melbourne with the CI422 electrode, and data from other published series, to determine the factor(s) influencing delayed loss. Then we consider a physiological mechanism that may contribute to delayed hearing loss, namely endolymphatic hydrops.

Clinical data: The clinical studies revealed that pre-operative hearing thresholds and the hearing loss over the first 3 months after surgery (early hearing loss) were seldom correlated. Neither was there a relationship between pre-operative hearing and long-term (>12 month) hearing loss. Early and long-term hearing losses were positively correlated (r^2 0.7-0.9). Early hearing losses were correlated across frequency (r^2 0.55-0.86). It may be concluded that the main determinant of long-term deterioration in hearing following CI is the extent of hearing lost at surgery. We deduce that the mechanism(s) for delayed loss appear to be independent of the extent of cochlear degeneration prior to implantation but are rather, related to the extent of initial injury during surgery.

Experimental data: EH has recently been seen in approximately a third of cochleae 3 months following experimental cochlear implantation (Lee et al, Audiol Neurotol, 2013). Similarly EH has been found in over 50% of cases in a human cadaveric study of CI recipients (Handzel et al, Otol Neurotol, 2006). In light of these observations, we have undertaken an experimental study to assess the prevalence of hydrops early after CI. CI was undertaken in the guinea pig. Electrocochleography (ECochG) was performed at surgery and at the end of the experiment. Cohorts of animals survived for time intervals up to three months. On micro-CT, hydrops was seen in the majority of cochleae 1 day and 1 week after CI. ANOVA revealed that, both the time after CI surgery and the ear tested (implanted or not) contributed significantly to the variance. On ECochG, the SP/AP ratio was significantly higher at a week after surgery. These findings suggest that even in the absence of significant injury to the cochlear duct, EH is prevalent after CI so that if it were to persist, it could potentially cause a delayed hearing loss.

Acoustic Implants and Objective Measurements

Dr. Ad Snik

Introduction. Objective measurements on acoustic implants have been carried out for two reasons. Firstly, to optimized intraoperatively the coupling of the implant's actuator to the ossicular chain or cochlear window and, secondly, to measure post-op maximum output and gain.

To measure coupling effectiveness, ECOG, ABR and ASSR measurements have been used as well as measurement of current uptake by the (loaded) actuator or by measuring sound in the ear canal, produced indirectly by the actuator. Experimentally, LDV has also been used. Post surgery, measuring the maximum output and gain, LDV has been used as well as measurements of produced sound in the ear canal. The latter application requires a healthy, mobile middle ear system (so that the tympanic membrane can act as a loudspeaker), however, in case of powerful actuators, measurement of the directly radiated sound by the actuator can also be measured in the ear canal.

Method. Literature was reviewed,

Discussion and conclusions. Concerning the intraoperative measurements. Verhaegen et al discussed sensitivity in relation to measurement time. Reliable testing requires much time. The use of LDV is not easily done. On the other hand, the Otologics method to measure loading of their actuator by monitoring current works fast (in patients with the classical application) and seems to be adequate.

To measure MPO, measurements in the occluded ear canal are simple and accurate. This method works in sensorineural hearing loss, and in mixed loss with powerful actuators. It also works with any type of bone conductor implants. In this way the input level at saturation of the device is determined; to derive the maximum output, the gain has to be determined as well in a separate (behavioral) experiment. Using such data, a model was developed that categorizes the implantable amplification options for patients with either sensorineural, conductive or mixed hearing loss.

Friday, October 17, 2014

Discussion IV: The Unique Fitting

Congenital Pitch Deficits: Implications for cochlear implant users

Dr. Alexandre Lehmann

Lehmann, A., Cousineau,M. & Peretz,I.

Congenital amusia is a neurogenetic disorder, characterized by a lifelong deficit in music perception and production. Amusic individuals share behavioural traits with cochlear implant (CI) users in that they all suffer from a deficit in pitch perception. However, the extent of the impairment is larger in CI listeners (for whom it is not rare to observe pitch thresholds as large as an octave, as opposed to a few semitones in amusics). The origin of the deficit also differs between CI listeners, who receive a degraded input through the implant, and the amusics whose deficit is associated to cortical connectivity abnormalities.

Here we present the results of recent studies conducted in our lab and identify cortical and subcortical correlates of this impairment. We show that : (1) amusia affects how pitch patterns are processed in cortical and auditory brainstem structures and (2) demonstrate a pitch-specific deficit in fine spectro-temporal information processing that is unrelated to temporal or spectral coding in the periphery.

We will discuss to what extent the distinct origin of the pitch deficit found in amusia may impact on the uses and functions of music in users of cochlear implants.

Bilateral Cochlear Implants: The potential utility of objective measures in maximizing benefits

Dr. Ruth Litovsky

Objectifying measures with children and adults who are fitted with bilateral cochlear implants

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We are interested in hearing abilities in bilaterally implanted listeners, in particular in auditory skills involved in navigating everyday listening situations. Recent studies in our lab have focused on the use of objective measures to account for the variability in performance. First, we are investigating sensitivity to binaural cues, which is likely to be affected by differences between the ears in terms of insertion depths of the cochlear arrays, spread of excitation / channel interaction, and neural pathology. Variability in binaural

sensitivity can arise within a subject (for different places of stimulation along the basilar membrane) and between subjects. Using electric compound action potential (ECAP), we are comparing neural spread of excitation along the basilar membrane under a number of binaural conditions. Results show that listeners' ability to extract binaural cues in noise is correlated with their degree of overlap in excitation patterns between adjacent electrodes. Further studies are investigating the predictive validity of ECAPs for other aspects of binaural hearing. Second, we are investigating speech understanding in bilateral cochlear implant users. Pupillometry is a tool that enables us to obtain an objective index of cognitive effort in a variety of listening conditions. Pupillometry has been used for numerous speech perception measures and can potentially be used for lower-level auditory skills and binaural hearing in order to evaluate and eventually improve performance. If objective measures can explain variability in psychophysics there may be an opportunity to use these tools for improving bilateral cochlear implant fittings, particularly for young children.

Support provided by NIH-NIDCD (R01DC003083, R01DC008365).

A New Chip to Record eCAPS During Continuous Stimulation

Dr. Johan Frijns

Johan H.M. Frijns (LUMC), Cees-Jeroen Bes (TU Delft), Jeroen J. Briaire (LUMC) and Wouter Serdijn (TU Delft),

Objectives: Development of a single chip, low noise, high bandwidth and power efficient readout system for neural responses in cochlear implants, ultimately enabling eCAP recordings during continuous stimulation.

Background: The recording systems used for reading out the evoked compound action potential (eCAP) in existing cochlear implants are restricted due to the occurrence of saturation in the single channel amplifier and analog to digital converter (ADC), and the relatively high internal noise levels. Consequently, eCAPs are generally recorded at the upper end of the subjective electrical dynamic range, which limits the clinical relevance of these measurements.

Methods: An overall readout system design is proposed containing an additive instantaneous companding input system that is able to record the eCAPs from the stimulated auditory nerve with a 126 dB dynamic range, thereby covering both stimulus artefact (up to 20V) and the neural response (down to 10μV).

Results: The first generation of the chip was hampered by the external control system. Currently the second chip is being evaluated. The system functions well under various wave forms. The rate of operation is still limited due to the external control chip (bandwidth up to approximately 15kHz). The maximum amplitude change that can be followed is now 0.5 V per 1.2 μs. Animal experiments in guinea pigs are underway.

Conclusions: The readout system is showing promise to reach its set targets. The limitations due to the external control chip will be resolved in the third generation that will fully integrate the companding and control systems in a single design. It holds a promise to enable eCAP recordings during continuous (speech) stimulation over the whole dynamic range.

Discussion V: The Unique Benefit

Functional near-infrared spectroscopy reveals cross-modal reorganization

Dr. Doug Hartley

Rebecca Dewey and Douglas Hartley

Studies using functional magnetic resonance imaging (fMRI), electroencephalography (EEG) and magnetoencephalography (MEG) suggest that deafness is associated with cross-modal reorganisation within auditory cortex. However, it is unknown whether this reorganisation influences restoration of hearing with a cochlear implant (CI) since most recording techniques are plagued by implant-related magnetic and/or electrical artefacts. No such artefacts are associated with neuroimaging recordings using functional near-infrared spectroscopy (fNIRS) or positron emission tomography (PET). However, the latter is unsafe for repeated use. Subsequently our group uses fNIRS to study cross-modal plasticity following hearing loss and cochlear implantation. Recently we investigated responsiveness of auditory cortex to visual and somatosensory stimulation in 29 profoundly-deaf (mean age 41±11 years) and 30 normal-hearing (mean age 34±13 years) adult participants.

Visual stimuli consisted of white dots moving with either random or coherent motion on a black background and somatosensory stimuli were 10 or 20 Hz sinusoidal vibrations presented to the palms and fingers of both hands. Each stimulus was presented for 20s and repeated 5 times in a pseudo-random order interleaved with a variable rest period of 25 - 45s. fNIRS data were acquired using a 24-channel Hitachi ETG4000 system. Psychophysical measures of coherent visual motion sensitivity and somatosensory frequency discrimination were assessed in a separate session.

Temporal lobe responses to visual and somatosensory stimulation were larger in profoundly-deaf participants compared with normal-hearing individuals, particularly over the right hemisphere. However, psychophysical results suggested that visual motion sensitivity and somatosensory frequency discrimination was similar between the groups. While our fNIRS data support the suggestion that auditory deprivation is associated with cross-modal reorganisation in auditory cortex, particularly in a brain region associated with speech processing, this reorganisation is not necessarily accompanied by supranormal visual or somatosensory perception.

Our results suggest that deafness-induced cross-modal reorganisation in auditory cortex can be assessed using a neuroimaging technique that is compatible with a cochlear implant. Ongoing studies being conducted by our group aim to assess cortical responses to multi-modal stimulation before and after cochlear implantation, along with psychophysical assessments of multisensory perception. We hypothesise that fNIRS may provide a useful prognostic indicator and/or objective measure of performance following cochlear implantation.

This work is supported by the University of Nottingham and the NIHR.

Electrophysiological signatures of audio-visual interactions in cochlear-implant users

Dr. Pascale Sandmann

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Cochlear implants (CI) can partially restore hearing, but the cortical changes underlying auditory rehabilitation are not well understood. The better understanding of experience-related changes in CI users is of clinical relevance because targeted therapies that can stimulate plasticity may accelerate aural rehabilitation and enhance speech comprehension with a CI. We performed a prospective longitudinal study with electroencephalography (EEG) which aimed to better describe the temporal dynamics of auditory cortex adaptation during auditory rehabilitation with a CI. Postlingually deafened CI recipients (N = 11; mean: 59 years) were tested after < 1 week, 8 weeks, 15 weeks, and 59 weeks of CI use by means of a discrimination task with different frequency-modulated tones (auditory condition) and patterns of coherent motion (visual condition). The CI users revealed a remarkable improvement in auditory discrimination ability which was most pronounced over the first eight weeks of CI experience. At the same time, CI users developed N1 auditory event-related potentials (AEP) with significantly enhanced amplitude and decreased latency, both in the auditory cortex contralateral and ipsilateral to the CI. A correlation was found between the AEP latency and the duration of deafness. For the visual condition, our results revealed a decrease of the P1 visual event-related potential (VEP) amplitude. These results suggest a rapid adaptation of the bilateral auditory cortex in middle-aged and elderly postlingually

deafened CI recipients, and indicate that rapid cortical adaptation to the implant signal is not limited to CI children but takes also place in adult individuals receiving an implant at advanced age. Furthermore, our results point to limited cortical adaptation in particular after long duration of auditory deprivation and suggest associations between changes in the visual and auditory modality during CI rehabilitation. The clinical implications of these results as well as the changes in the interaction between the auditory and the visual modality following implantation will be discussed.

Effects of unilateral deprivation in development measured using electrophysiology

Dr. Daniel Wong

Congenital unilateral deafness results in restricted input along the auditory pathway, potentially resulting in permanent reorganization. We examined whether early unilateral implanted hearing alters the development of the auditory pathways and whether a second implant can restore normal development.

Multichannel electroencephalography measurements were recorded from 34 children with cochlear implants and 7 normal hearing peers. In order to characterize auditory cortex response amplitude from data contaminated by the electrical artifact generated by the cochlear implant, a beamformer was implemented to spatially estimate the signal across the brain volume. The beamformer was also constrained to minimize contributions from artifact sources as identified by their sensor distribution. Age dependent MRI templates were used to generate boundary element volume conduction models for the beamformer.

Amplitudes of beamformer-estimated activations in the auditory cortices were used to characterize the lateralization of the responses. Factor analysis was used to examine the potential influence of factors related to age and time of implantation. Lateralization in response to stimulating either the first or second implanted ear was found only to be dependent on duration of unilateral hearing. Regression analysis showed that differences in hemispheric lateralization from patients who received both implants at the same time became significant at ~1.5 years of unilateral implant use. By dividing the CI patients who received their 2nd implant before 1.5 years of unilateral implant use from those who received it after, we showed that only in the latter group was hemispheric lateralization significantly different from normal.

These results demonstrate that the developing auditory pathway reorganizes in response to unilateral stimulation and that there is a sensitive period whereby bilateral auditory input provided with a minimal delay can protect the brain from these potentially permanent changes.

Phonological reorganization of the postlingual deaf and its implication for cochlear implant outcome. Evidence of plasticity from fMRI studies

Dr. Diane Lazard

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Not having access to one sense profoundly modifies our interactions with the environment, in turn producing changes in brain organization. Deafness and its rehabilitation by cochlear implantation offer a unique model of brain adaptation during sensory deprivation and recovery. Oral communication difficulties induced by post-lingual deafness shape cortical reorganization of brain networks already specialized for processing oral language. Cochlear implants (CI) work well, yet the outcome is not fully accounted by the data routinely available to the clinician. Using fMRI in deaf adults, candidate for a cochlear implantation, and matched normal hearing controls, we explored phonological processing from written material. For easy rhyming tasks, some deaf subjects relied on the ventral lexico-semantic route and right areas, not usually involved in phonological processing. When the tasks were designed to force the use of the dorsal phonological route, some deaf subjects processed phonology faster than hearing controls, without accuracy loss. This paradoxical cognitive gain was mediated by a functional interaction between early visual cortex and the left inferior prefrontal cortex, which by-passed the graphemic and phonological steps usually taking place in left fusiform gyrus and superior temporal cortex. Accelerated phonological

processing was accounted for by the recruitment of the right superior temporal sulcus, an area usually involved in paralinguistic processing. In the two experiments, those deaf subjects who showed phonological reorganization of right areas lately became poor CI performers. These data suggest that maintaining active left auditory-based phonology may preserve the possibility to revert to hearing. By contrast optimizing written communication (reading) engaging right areas may compromise future auditory restoration.

Saturday, October 18, 2014

Introduction to Cochlear Implantation in Older Adults

Dr. Frank R. Lin

Older adults represent the fasting growing segment of the population in many countries with populations that are rapidly aging. Among this growing population of older adults, greater than 1 in a 100 could likely benefit from CI but <5% in most countries have received a CI. This introduction will briefly introduce the physiological, environmental, and social issues that are unique to geriatric populations when considering CI and also discuss the role of objective measures and outcomes in the broader context of healthy aging.

Industry panel

Objective Measures of Structure Preservation in Modern CI Patients

Dr. Claude Jolly

Structure preservation in hearing preservation surgery can be demonstrated by evaluating post op residual hearing. The importance and demonstration of structure preservation could not have been established without the initial rise of hearing preservation electrodes and surgical techniques. CI electrodes and surgical techniques designed for hearing preservation and for combined electric acoustic stimulation(EAS) or partial deafness treatment not only require the preservation of the fragile scala tympani tissue from base to apical region, it also requires minimal interferences with micro structures, mainly inner and sometime outer hair cells. Furthermore hearing preservation as a subset of structure preservation requires the maintenance of the endocochlear potential. Hearing preservation of whatever measurable degree demonstrates that the electrode is strictly into scala tympani without translocation. This is true even if residual hearing is lost some time after surgery. A complimentary way to infer structure preservation in patients with little or no residual hearing is to observe and compare sacular functions between pre and post op. VEMP and caloric functions if there are unaffected could testify for the insertion quality. Post op dizziness could indicate an undesirable event caused by electrode insertion. Of recent interest worldwide has been post op imaging able to demonstrate the electrode position intra scala after insertion. New imaging modalities such as cone beam computer tomography use reduced radiation while preserving a detailed view of electrode position within the inner ear. Major structural damage can be inferred when the electrode is reported to translocate. Some pre shaped electrodes inserted through cochleostomy translocate about 50% of the time when the literature is scrutinized. Such a high rate of translocation even in the hands of the best surgeons is an unacceptable situation for patients, adults and children. Theoretically a high degree of structural preservation after electrode insertion or removal does not preclude the eventual reversibility of cochlear implantation through gene and stem cell therapies. There are however no therapies which can repair structural damage to the cochlea. Considering the human life expectancy progresses it can be stated that the probability of CI replacement in the young and very young population is 100%, for all devices and all manufacturers, and most likely more than once in a lifetime. With the introduction of fully implantable CI necessitating battery replacement every 10 years or less it is essential that the electrode array insertion and explantation process do not accumulate tissue and neural damage.

Objective Measures in Elderly Cochlear Implant Subjects

Dr. Ernst von Wallenberg

Ernst von Wallenberg (Cochlear AG), Christopher J. Long (Cochlear Ltd.)

Aim: To review objective measures which could be performed in the elderly cochlear implant population to improve outcomes for the individual recipient.

Background: In some regions served by Cochlear Ltd. in the year 2013, as many as 40% of subjects receiving cochlear implants (CI) were above 65 and 13% were above 80 years of age at the time of implantation. Elderly CI subjects have demonstrated good performance in speech understanding and a high-level of benefit in the quality of life (Sterkers 2012). Unfortunately, there is still much variability from recipient to recipient. One hypothesis concerning the wide range outcomes across recipients is the difference in neural survival patterns. Histopathologic studies have shown that spiral ganglion cell counts declined at a mean rate of 100 cells per year of life (Makary et al. 2011). Both age and duration of deafness have been shown to be significant predictors of speech understanding outcomes with cochlear implants (Blamey et al. 1992, 1996, 2013; Holden et al. 2013). A recent study of within-subject comparison of word recognition and spiral ganglion cell count in bilateral CI recipients demonstrated that differences in spiral ganglion cell counts were highly correlated with the differences in word recognition scores on both sides (Seyyedi et al. 2014).

Methods: Studies assessing methods to measure the neural survival patterns in implanted recipients were reviewed.

Results: We examined the relationship between focused stimulation thresholds, electrode positions and speech understanding in CI subjects. Our results suggest that speech understanding is highly impacted by individual patterns of neural survival and that these patterns manifest themselves in how well (or poorly) electrode position predicts focused thresholds (Long et al. 2014). Pfingst and Xu (2004) and Bierer (2007) have used psychophysical tests to determine the status of the electro-neural interface in CI recipients. An objective measure such as the slope of the Electrically Evoked Compound Action Potential (ECAP) growth function has shown significant correlation to performance with a cochlear implant (Kim et al. 2010). More recently it was demonstrated that selection of electrodes with good modulation detection thresholds (Garadat et al. 2012) or based on electrode position on CT scans (Noble et al. 2013) resulted in better speech recognition.

Conclusions: There are indications that through objective measures the individual's pattern of neural survival can be assessed and when applied to the sound processor program the recipient's performance can be improved.

Technology and Patient Specific Variables; What can we measure that can help us improve (or better understand) outcomes in elderly cochlear implant recipients?

Dr. Edward Overstreet

It is well recognized that technology alone is not a complete solution for hearing loss as numerous patient specific factors are known to contribute to outcomes in patients with a cochlear implant. At present, we are pursuing studies investigating the impact of cognitive load (and potential objective measures correlated with the same) on speech perception performance. In addition, effort is being made to better understand how to segregate patients according to specific factors (including age, cognitive capability and objective measures) to better enable the understanding of how specific technologies impact outcome. This presentation will provide an update of our current work in the above areas highlighting the consideration of these factors in the elderly population.

Scientific Panel

Effects of Hearing Loss and Aging on Remembering What Was Heard: In one ear and out the other?

Dr. Kathy Pichora-Fuller

Evidence will be presented for the following points:
1. Remembering a word depends on the quality of the sensory input;
2. Long-term reductions in the quality of sensory input due to auditory aging can alter memory processes;
3. Hearing impairment increases the risk of memory impairment in older adults.

Implications and future directions for practice will be discussed, including the issues of whether or not audiologists should test memory and how the results of such tests could be used to improve practice within and beyond audiology.

Measures of Peripheral and Central Auditory Plasticity

Dr. Paul Kileny

Measures of auditory plasticity are important considerations in the management and evaluation of cochlear implant candidates, and recipients. We usually refer to and consider neuro-plasticity as a desirable characteristic or outcome. For instance, we consider the attainment of normal evoked potential or event-related potential amplitudes and latencies in a cochlear implant recipient, as indicators of positive plasticity. One such specific example, is the absence of an acoustic ABR in patients with auditory neuropathy spectrum disorder, followed by the immediate presence of an electric ABR when switching from acoustic stimulation to electrical stimulation at the promontory. However, plasticity can also be negative, meaning certain changes over a certain time frame that may impact negatively on performance with a cochlear implant. An example of “negative” plasticity is the manifestation of rapid adaptation to electrical stimulation resulting in uneven auditory performance over time. Auditory plasticity can be also considered in terms of auditory periphery, or cortex. This presentation will address the evaluation of auditory plasticity in the auditory periphery using minimally invasive measures obtained preoperatively. These can be used to predict cochlear implant benefit, or challenges. The presentation will also address a novel optical brain imaging technique, functional near infrared spectroscopy (fNIRS), that holds promise as a tool for the investigation of cortical activation in patients with cochlear implants. This imaging technique involves the measurement of changes in oxygenated, and deoxygenated hemoglobin by monitoring the transmission of near-infrared light through brain tissue. Unlike evoked and event-related potential measures, this technique is free of electrical artifacts that plague evoked potential measures obtained from patients with cochlear implants.

Physiological Measures of Tinnitus and Their Challenging Interpretation

Dr. Jos Eggermont

Tinnitus is a conscious percept, and as such areas beyond auditory cortex need to be activated by any bottom-up physiological substrate. In animal experiments nearly all physiological recordings have been peripheral from and including primary auditory cortex. The cortical activity provides the information for the consciousness network. Human data have shown that hearing loss in itself affects part of this consciousness network, i.e., ventral medial prefrontal cortex (vmPFC), and in this way affects or potentially induces the tinnitus percept.

Animal studies on the effects of noise-induced hearing loss (NIHL) suggest that increased spontaneous firing rate (SFR) and increased spontaneous neural synchrony (SNS), often accompanied by reorganization of the cortical tonotopic maps, are the necessary bottom-up substrates for tinnitus. The fact that only 30% of people with NIHL complains about tinnitus suggests that they are not sufficient substrates for tinnitus. Furthermore, tinnitus without clinical hearing loss appears not accompanied by tonotopic map changes.

Neural imaging and EEG/MEG studies suggest that major changes occur in resting state neural networks in the brain in tinnitus patients, but the changes depend on, or are causal to, the annoyance thereof and to co-occurring depression. Neural imaging studies suggest that deafferentation resulting from hearing loss may be a dominant factor in reshaping cortical networks.

Partial deafferentation, overuse, attention and stress are known to induce plastic changes in the auditory system and potentially beyond. Some of these changes are rapid, and attributed to Hebbian mechanisms,

others are slow and reflect homeostatic mechanisms. Both types of plasticity complement each other and result in stable changes. Homeostatic mechanisms aim at offsetting the reduced afferent input resulting from hearing loss by increasing the synaptic gain. This, however, also increases the SFR and may trigger the tinnitus percept. However, these SFR changes are slow and do not explain short-duration tinnitus immediately following exposure to loud noise. In contrasts, in animals increases in SNS do occur nearly immediately following noise trauma and suggest different mechanism for transient and chronic tinnitus.

In the majority of cases, tinnitus is accompanied by hyperacusis—and increased responsiveness to sound—and clearly the result of a homeostatic gain change in the auditory system. Measurements of sound induced activity in tinnitus patients by either neural imaging or EEG/MEG measures is prone to the confound of this co-occurring hyperacusis and makes its study such a challenge.

Clinical Panel

Cochlear Implantation on the Medically Complex Patient: Medical and surgical considerations

Dr. Vincent Lin

Audiological indications for cochlear implantation has greatly expanded over the past decade. This has led to a growing number of hearing impaired individuals receiving tremendous benefit from the implant. Furthermore we are also implanting more individuals with complex medical co-morbidities. As a result these patients present a challenge to both the surgeon and anesthetist during cochlear implant surgery. The objective of this talk to is to discuss the surgical and medical management of complex patients and how these risks can be identified and minimized. Common co-morbidities such as heart disease, pulmonary disease, diabetes, arteriosclerosis, renal disease and dementia and their effects on surgery, anaesthesia and the peri-operative period will be discussed.

Electrophysiological and Behavioral Correlates of Auditory-Cognitive Processing in Older Adult Cochlear Implant Recipients

Dr. Yael Henkin

Yael Henkin, Yifat Yaar-Soffer, Meidan Steinberg, Chava Muchnik
Hearing, Speech, and Language Center, Sheba Medical Center, Tel Hashomer Department of Communication Disorders, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

A growing body of evidence suggests that older adults benefit from cochlear implants (CI). When compared to young CI recipients, however, older adults show greater variability in speech perception performance, and on average exhibit poorer outcome. Clinically used speech perception tests, though sensitive to some extent to the difficulties encountered by older CI recipients, do not tap into the cognitive aspects of speech understanding that affect the amount of attention and memory resources expended during communication. Auditory event-related potentials (AERPs), on the other hand, are advantageous for delineating auditory-cognitive processing as they allow evaluation of the time-course of cortical information processing, from early perceptual to later cognitive, post-perceptual stages. The present study was therefore designed to characterize auditory-cognitive processing in older-adult CI recipients by means of behavioral and electrophysiologic manifestations of Stroop tasks. AERPs were recorded from 32 scalp electrodes from older (age at CI>60 yrs) and young (age at CI 18-42 yrs) post-lingually deafened adults with CI and from age-matched controls with age-appropriate or normal hearing (NH). Older adults (CI and NH) filled the mini-mental state examination questionnaire. All participants performed an auditory Stroop task that included the words "mommy" and "daddy" produced by a male and a female speaker, and were required to classify the speaker's gender while ignoring the irrelevant (congruent or incongruent) word meaning. Results indicated that auditory-cognitive processing in young NH and older age-appropriate NH adults was similar with respect to performance accuracy, Stroop effect magnitude, and sensory-perceptual processing (P1, N1, P2 latency). Differently from young adults older adults exhibited prolonged higher-order perceptual processing (P3) and reaction time, significantly lower prevalence of the neural events reflecting higher-order perceptual (N2) and post-perceptual (N4)

processing, and enhanced neural activation in auditory areas. Comparison between auditory-cognitive processing of older CI users and older NH listeners revealed similar findings with respect to Stroop effect magnitude, sensory-perceptual processing (N1), and absence of post-perceptual neural events (N4). In contrast, older CI users showed poorer performance accuracy and prolonged higher-order perceptual processing (P3 latency) compared to older adults with age-appropriate NH. Preliminary data from young CI recipients show similar auditory-cognitive processing compared to young NH listeners (performance, reaction time, P3 and N4 latency). Taken together, AERPs and behavioral measurements during Stroop tasks unraveled the effects of age and cochlear implantation on auditory-cognitive processing.

Social Isolation as a Factor in Implant Candidacy and Outcomes

Ms Marilyn Reed

There is a growing body of literature demonstrating an association between poor hearing abilities and other health outcomes. Many studies have shown that the inability to communicate effectively affects socialisation, independence, participation in activities of daily living (ADLs), and consequently, emotional, psychological and social well-being. This is particularly true for seniors with severe or profound hearing loss, who typically receive limited benefit from hearing aids and are therefore candidates for cochlear implants. Due to the severity of their communication difficulties, they are unable to participate in groups and choose to withdraw and avoid social encounters rather than deal with their challenges and frustrations. Exacerbated by other physical and cognitive changes associated with aging, the resulting social isolation often leads to loneliness and depression.

Social interaction is a key determinant of successful aging, and the prevention of social isolation was identified as the focus of study for Canada's National Senior's Council in 2013/14. Recent research is showing that social isolation in older adults negatively impacts morbidity and mortality through both psychological and physiological pathways. Hearing loss has also been found to be independently associated with the development of dementia, with one of the most likely pathways being through the imposed isolation and negative impact on quality of life.

Candidacy criteria for auditory implants have expanded and evolved over time as advances in technology have resulted in improvements in performance outcomes. Older adults make up an increasing percentage of implant recipients, as age is no longer a barrier for candidacy. Given that social isolation is such a frequent consequence of severe hearing loss in the elderly, with such significant impacts on health and well-being, it would seem to be important to consider it in any implant program.

This presentation will discuss why social isolation should be included as a factor in determining candidacy for implantation, and offer some tools that have been employed in its measurement.

Open Paper Abstracts

Open Paper Abstracts

O01

Speech recognition after cochlear implantation depends on a-specific neural metabolic activity in prelingually deaf adults

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Objectives

The aim of this study was to find out whether brain activity can be used to predict the speech recognition performance after implantation in prelingually deaf adults.

Background
Prelingually deaf adults generally show limited improvement and large variability in speech recognition after implantation, potentially as a result of cross-modal reorganisation of the auditory cortex by visual functions.

Methods
In this study we measured brain glucose metabolism with [^{18}F]-fluorodeoxyglucose positron emission tomography in 11 prelingually deaf adults before (6 of 11) and after (9 of 11) implantation and in 4 normal-hearing subjects to study its relation to speech recognition after implantation.

Results
Compared to normal hearing individuals, the prelingually deaf generally had increased glucose metabolism in temporal and occipital regions, while there was no credible difference in the deaf before and after implantation. Hemispheric differences were observed in several cortical and cerebellar regions. Presentation of a video (both with and without audio) yielded a larger glucose uptake in occipital regions than during rest. No interaction effect (e.g. between groups and stimulus modality) was credibly present. The performance of prelingually deaf subjects on speech recognition one year after cochlear implantation correlated with glucose uptake in several brain regions: notably, negatively with superior temporal gyrus glucose uptake during rest and video presentation and positively with activity in the pars orbitalis of middle frontal gyrus in all stimulus conditions.

Conclusions
These activation patterns might suggest that an increase of a more general, a-specific brain activity is a better predictor of poor implantation outcome in late-implant prelingually deaf than early auditory-to-visual cross-modal reorganisation.

O02

Functionality of the auditory nerve after neurotrophic treatment in deafened guinea pigs assessed with electrically evoked action potentials

Dyan Ramekers (University Medical Center Utrecht) Huib Versnel (University Medical Center Utrecht) Stefan Strahl (MED-EL GmbH R&D) Wilko Grolman (University Medical Center Utrecht) Sjaak Klis (University Medical Center Utrecht)

The study is supported by MED-EL GmbH

Objectives
To investigate the long-term neuroprotective effect of treatment with a neurotrophic factor in the deafened cochlea with emphasis on the functionality of the auditory nerve.

Background
After severe damage to the organ of Corti spiral ganglion cells (SGCs) degenerate. Local treatment with exogenous brain-derived neurotrophic factor (BDNF) prevents SGC degeneration even several weeks after cessation of the treatment. Functionality of neurotrophically treated SGCs has not been examined yet using electrically evoked compound action potentials (eCAPs).

Methods
Two weeks after deafening by kanamycin and furosemide, guinea pigs were implanted with an intracochlear electrode array with a cannula connected to an osmotic pump filled with BDNF. Four weeks later the treatment was stopped by surgically removing the osmotic pump. Another eight weeks later eCAPs were recorded after which the animals were sacrificed for histological analysis of the SGCs. The functional condition of the SGC population was characterized by varying the inter-phase gap (IPG) of the biphasic electric pulse (Ramekers et al., JARO 15:287-202, 2014).

Results
Both directly and eight weeks after BDNF treatment, SGC packing density was well preserved in basal and middle cochlear turns. Accordingly, the eCAP amplitude was larger in BDNF-treated animals than in untreated deafened controls. The eCAP measures obtained by varying IPG in BDNF-treated animals were comparable to those measures in normal-hearing animals, in contrast to those measures in untreated controls.

Conclusions
BDNF treatment prevents SGC degeneration on the long term. Importantly, various eCAP characteristics indicate that this treatment also preserves functional properties of the SGCs.

O03

Objective Measures of Neural Status and Neurotrophic Support

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Research and presentation supported by NIH and MED-EL.

Objectives
To use objective noninvasive measures to monitor neural status near cochlear-implants, monitor the

effects of neuronal therapy, and guide fitting strategies.

Background
In previous studies we have demonstrated the importance of cochlear health for cochlear implant function. The current study used gene-therapy procedures for improving neural health and used noninvasive objective measures to monitor the results.

Methods
Mature male guinea pigs were trained to perform psychophysical stimulus-detection tasks. Ears were deafened with neomycin. The experimental group (n=16) was inoculated in one ear with an adeno-associated viral vector with a neurotrophin gene insert (AAV.*NTF-3)* and then implanted. The control group (n=5) was deafened and inoculated with an empty AAV. Comparison groups were implanted without deafening (n=20) or neomycin deafened with no neurotrophin therapy (n=9). Psychophysical multipulse-integration (detection threshold versus pulse rate; MPI) functions and ECAP and EABR amplitude-growth functions were monitored for 5 to 14 months after implantation. The guinea pigs were then euthanized and the cochleae were processed histologically to assess spiral ganglion neuron (SGN) health and density.

Results
MPI functions were steep only in animals with high (>70% of normal) SGN densities. SGN density was positively correlated with slopes of ECAP and EABR amplitude-growth functions across the full range of SGN survival (2% to 88%).

Conclusions
.MPI, ECAP and EABR measures are reflective of various levels of cochlear health. Ongoing work shows that they are predictive of speech performance in people with cochlear implants and thus can guide fitting strategies.

O04

Cochlear Implantation in unilaterally deaf adults and children

Antje Aschendorff (University of Freiburg) Susan Arndt (University of Freiburg) Frederike Hassepass (University of Freiburg) Rainer Beck (University of Freiburg) Thomas Wesarg (University of Freiburg) Roland Laszig (University of Freiburg)

Background
Cochlear implantation is the common treatment modality for rehabilitation in bilaterally deaf patients. Auditory rehabilitation is still discussed in case of unilateral deafness or asymmetric hearing loss (AHL) where the second ear is not within the criteria for a cochlear implant.

Objectives
To evaluate results of different ways of auditory rehabilitation in single-sided deafness and asymmetric hearing loss in adults and children.

Methods
In a single center study 101 adult patients with severe to profound AHL were examined before and after testing CROS hearing aids and BAHS. CI was recommended if the patients met our inclusion criteria for CI: duration of deafness ≤ 10 years, intact auditory nerve. Speech reception thresholds were examined in 3 different speech in noise presentation conditions S0N0, S45N-45 und S-45N45, as well as localization capability 12 months and 24 months after first fitting. Subjective assessment of hearing with and without CI was evaluated with the SSQ questionnaire. Three children with acquiered hearing loss were evaluated in the same mode as well.

Results
The speech reception results of the chosen devices (CROS HA, BAHS or CI) after 12 months were compared. Patients with a CI showed significantly better localization ability and speech understanding in noise compared to the patients with conventional hearing aids. The results were consistent even after 24 months. The rehabilitation results of the unilaterally deaf 3 children 12 months after CI-fitting are equal or better than the results of our adult patients after CI surgery.

Conclusions
The results of the adult patients as well as the children demonstrate that single-sided deaf patients benefit from a cochlear implantation with consistent results over time. Subjectively and objectively, cochlear implantation is the most successful method of hearing rehabilitation in patients with asymmetric hearing loss and single sided deafness.

O05

Unilaterally-driven cortical maturation leads to lasting asymmetries in the bilateral auditory pathways in adolescents who are deaf and use one cochlear implant

Salima Jiwani (The Hospital for Sick Children) Sam Doesburg (The Hospital for Sick Children) Blake Papsin (The Hospital for Sick Children) Karen Gordon (The Hospital for Sick Children)

No conflicts of interest to declare

Objective
To assess whether unilaterally-driven maturation of the auditory cortex with a cochlear implant (CI) leads to abnormal reorganization in the bilateral auditory pathways.

Background
Unilateral CI stimulation restores hearing to children who are deaf, but compromises auditory development if a second implant is not provided within 1.5 years. We are now exploring whether missing this sensitive period and driving maturation of the auditory cortex with over a decade of unilateral CI use causes permanent abnormalities in cortical activity and reorganization in the deprived pathways.

Methods
Electrically-evoked cortical responses were recorded at 64 positions on the head in 34 adolescents who used a right CI for over 10 years before receiving a second implant in their deprived left ear. Cortical activation underlying the evoked peaks was localized to different areas of the brain using our beamformer imaging method. Neural synchrony of these responses was calculated to assess the co-ordination of activity across brain regions in response to sound.

Results
Long-term unilateral right CI stimulation drove abnormally strengthened activity from the hearing ear to the contralateral auditory pathways and increased synchrony in networks known to be involved in cognitive processing. Deprived pathways were abnormally segregated from this network. Activity evoked in the deprived side with the second CI was distributed across both cortical hemispheres with synchronized oscillations reflecting increased inhibition.

Conclusion
Unilaterally-driven cortical maturation causes lasting asymmetries in auditory pathways and altered neural networks, perhaps marking the closure of a sensitive period for restoring normal-like auditory function on the deprived side.

O06

Auditory evoked potentials for direct acoustic cochlear stimulation

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Direct Acoustic Cochlear Implants (DACIs) directly stimulate the cochlear fluid of the inner ear by means of a stapes piston driven by an actuator in the middle ear, and are indicated for severe to profound mixed hearing loss. Auditory evoked potentials (AEPs) recorded in such patients would allow the objective evaluation of the aided auditory pathway.

The aim of this study was (1) to develop a stimulation setup for EEG recordings in patients with Cochlear DACIs, (2) to show the feasibility of recording auditory brainstem responses (ABRs) and auditory steady state responses (ASSRs) and (3) to analyze the relation between electrophysiological thresholds derived from these responses and behavioral thresholds. For the 3 subjects implanted during the phase Ib clinical study in our center, ABRs and 40 and 80 Hz ASSRs were recorded with a straight-forward acoustic stimulation setup and a newly developed direct stimulation setup.

With the acoustic stimulation setup, stimulation artifacts made it impossible to analyze responses. With the direct stimulation setup, stimulation artifacts could be removed completely, and responses could be successfully recorded in all subjects. Response properties such as ABR peak V latencies and ASSR apparent latencies were similar to those for acoustic stimulation, and electrophysiological thresholds derived from 40 Hz ASSRs corresponded very well to behavioral thresholds.

The results show that AEP measurements with the developed direct stimulation setup are feasible and meaningful and could potentially be used to provide intra-operative feedback about the coupling of the actuator to the inner ear.

O07

Objective assessment of preoperative steroids on hearing preservation cochlear implantation

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Med-El sponsored registration and travel to conference

Objectives
To determine if preoperative steroids can improve outcomes in cochlear implant users and if its effects can be measured electrophysiologically.

Background
Hearing preservation cochlear implant surgery has become the standard approach for patients with residual hearing. There have been several methods proposed to improve the rate of hearing

preservation, including the use of corticosteroids. Intraoperative steroids given preoperatively for otoprotection have become more popular due to evidence in animal studies and its use in otologic emergencies. However there are currently no published randomised controlled trials of steroid use in cochlear implantation. Electrophysiological measures including the electrically evoked compound action potential (ECAP) and cortical auditory evoked potentials (CAEP) have been shown to be measures of neuronal physiology and therefore are potential objective measures of the steroid effects.

Methods
31 patients with low frequency residual hearing undergoing cochlear implantation with a Med-EL Flex 28 electrode were enrolled in a tertiary academic centre. Surgeons were blinded and round window insertion was performed in all cases. Patients were randomised to receive dexamethasone transtympanically one day prior to surgery, oral prednisolone 6 days prior to surgery, or a control group. Post operative outcome measures were perfomed at 1week, 1 month, 3 months, 6 months and 12 months after switch on. These included pure tone audiometry, speech discrimination in quiet and noise, ECAPs and CAEPs.

Results
Preliminary outcomes of the first 18 patients show that the oral steroid group have a greater mean ECAP slope than control at progressively more basal electrodes over time. The oral steroid group also had a greater mean ECAP slope than the transtympanic steroid and control group at basal electrodes ($p < 0.05$). Both steroid receiving groups have higher ECAP thresholds compared to control ($p < 0.05$), and higher MCLs (maximum comfort levels) and larger dynamic ranges. The transtympanic steroid group had the lowest impedances compared to control up to 6 months post surgery ($p < 0.05$). Higher ECAP slopes and thresholds have been shown to correlate with greater neuronal survival. CAEPs showed no differences between the groups, confirming the local effect of steroids. The outcomes including hearing and speech discrimination will be presented for the remaining patients

Conclusions
The preliminary outcomes indicate that steroids have clear effects on the ECAPs and electrode impedance, particularly in the basal portion of the cochlea. This finding correlates with our animal study showing that systemic and transtympanic steroids have primarily basal effects. This has implications for future steroid delivery techniques, targeting the apical region of the cochlea. We present the outcomes of the first randomised control trial for steroid use in hearing preservation cochlear implantation.

O08

Electrophysiological Monitoring of Residual Hearing Before, During and After Cochlear Implantation

Adrian Dalbert (University of Zurich) Jae Hoon Sim (University of Zurich) Alexander M. Huber (University of Zurich)

Identify any real or apparent conflict(s) of interest.

Objectives:
To identify optimal electrophysiological methods to assess cochlear function before, during and after cochlea implantation and to perform a clinical study to further elucidate causes and time of residual hearing loss of after cochlear implantation surgery.

Background:
Preservation of residual acoustic function during cochlea implantation has been shown to be beneficial for patients that still have functional residual hearing at the time of implantation. Surgical techniques, local or systemic drug therapy and specially designed electrodes have been proposed to minimize damage of the residual hearing caused by cochlear implantation surgery. Thereby favorable preservation results have often been achieved. However, residual hearing may still be lost or deteriorated. Much of the underlying

processes leading to such acoustic threshold shifts remain unclear.

Methods:
In patients undergoing cochlear implantation, standard psychoacoustic tests of residual auditory function and objective electrophysiological measurements were performed before and after implantation. For eletrophysiological assessment an electrode was placed close to the round window and Electrocochleographic (ECoG) function was recorded before during and immediately after cochlear implantation. In addition recordings were performed via the cochlear implant itself during surgery and the usual follow up and fitting appointments. Electrophysiological results were compared to the psychoacoustic testing.

Conclusion:
Frequency specific electrophysiological monitoring during and after cochlear implantation was possible by ECoG even in patients with very limited residual hearing. Hearing loss during surgery could be estimated by round window ECoG recordings. Postoperative electrophysiological monitoring of residual hearing is possible using the CI electrodes for measurements. This gives further information about time and cases of loss of residual hearing.

O09

Intracochlear pressure changes related to different insertional speeds of cochlear implant electrodes

Ingo Todt (Unfallkrankenhaus Berlin) Arne Ernst (Unfallkrankenhaus Berlin)

Introduction:
The preservation of residual hearing, prevention of vertigo and tinnitus are beside a optimal audiological outcome the aims of a a modern cochlear implant treatment. Beside new electrode designs other factors are of growing interest which might influence or determine an atraumatic insertion of a cochlea implant electrode. One factor is the speed of insertion. But the knowledge about it is still limited.
The aim of the present study was to observe the intracochlear pressure changes related to different insertional speeds in a cochlear model.

Material and methods:
All insertions were performed with an Advanced Bionics IJ electrode and an insertional tool at a model. The different defined insertional speeds (1mm/sec., 0.5 mm/ sec., 0.1 mm/ sec.) were performed with a linear actor. The evaluation of the pressure changes was performed with an micro sensor.

Results:
We observed a correlation between the different insertional speeds and the increase of intracochlear pressure.

Conclusion:
The atraumatic insertion of cochlea implant electrodes is crucial for the preservation of residual hearing. In our model experiments, we were able to observe for the first time a relationship between insertional speed and intracochlear pressure changes.

O10

Status of the electrode array: Intra-Cochlear Impedance Matrix and its Clinical Relevance

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This study was supported by Cochlear Europe.

Objectives
To ensure adequate stimulation pattern to the auditory nerve a functioning electrode has to be in place. Aim of the study is to validate an algorithm for data analysis of the Intra-cochlear Impedance Matrix test (IIM). This procedure
- recognises faulty electrodes and
- classifies aberrant findings,

which cannot be found by standard clinical measurements.

Background
The IIM test is an experimental telemetric procedure for measuring intra-cochlear impedances. It combines the measure of bipolar impedances of each electrode against each other electrode; the common ground measurements serve as references for normalisation.

Methods
In a multi-centre study 192 implants were investigated. This data pool of 163 normal and 29 atypical datasets with known abnormalities was split for further evaluation. It was divided into a training group - to create an algorithm for automatic data analysis and into a control group - for evaluation of sensitivity and specificity of the newly developed algorithm.

Results
The quantity and the type of deviation from the normative data were evaluated by a set of distance measures to provide an indication and measure of abnormality. Potential abnormalities could be detected with a high level of reliability. Results in the control group indicated a specificity of 0.84 and sensitivity of 0.98.

Conclusions
The IIM procedure is fast and has good reproducibility. The measurement is not too loud and is therefore acceptable for both adults and children.
The IIM test was more accurate than the clinical gold standard in several cases and allows a more differentiated point of view on the status of the electrode array with more detailed conclusions compared to standard impedance measurement.

O11

Evaluation of insertion depth and intra-scalar electrode array position of the HiFocus Mid-Scala and HiFocus 1J electrode array.

Annerie van der Jagt (Leiden University Medical Center) Jeroen Briaire (Leiden University Medical Center) Berit Verbist (Leiden University Medical Center) Johan Frijns (Leiden University Medical Center)

Objectives
Evaluation of insertion depth and intra-scalar position of the straight HiFocus1J and pre-curved HiFocusMS (Mid-Scala) implant electrode arrays (Advanced Bionics).

Background
The HiFocusMS electrode was designed for a mid-scalar placement in the scala tympani. It has a shallower target insertion depth than the HiFocus1J electrode and tries to protect the delicate cochlear structures and preserve any residual hearing, aiming for the best hearing outcomes.

Methods
123 HiFocus1J and 51 HiFocusMS electrode arrays were fully inserted through an (extended) round window approach. To study insertion depth and intra-scalar position of the electrode array, multiplanar reconstructions (MPRs) of postoperative CT scans were analyzed by applying a 3D coordinate system. The angular position, relative to the round window, of the most apical electrode was used to determine the insertion depth. The outer and inner cochlear wall were automatically traced by an in-housed designed algorithm.

Results
The mean angular insertion depth of the HiFocus1J electrode array population was 471° (SD 64°) compared to a value of 421° (SD 34°) for the HiFocusMS electrode array population. The four most basal electrode contacts of the HiFocusMS electrode array are placed in a peri-modiolar position and the remaining electrodes are positioned mid-scalar, while the HiFocus1J follows the outer wall along its whole trajectory.

Conclusions
Implantation of the HiFocusMS electrode array results in a 50° shallower and significantly less variable insertion than the HiFocus1J array. Apart from the basal contacts, the HiFocusMS electrode has a mid-scalar position, in line with its design criteria.

O12

The effect of scalar position on speech discrimination

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Objectives
To analyze the effect of scalar electrode position on the speech perception post cochlear implant.

Background
Speech perception following cochlear implant is influenced by a multitude of factors – most of them well

outside of the control of the surgeon. Nevertheless, the factors in control - like the scalar position of the electrode array - have to be evaluated carefully to ascertain the best outcome possible.

Methods
In the course of 2003 to 2009, all patients receiving a cochlear implant with a contour advance electrode array in a single tertiary referral center were identified retrospectively and the postoperative imaging (cone-beam tomography) was analyzed in regard to scalar electrode position. Speech perception scores (monosyllables, sentence discrimination) were fitted with a nonlinear mixed-effect model with and without the inclusion of the scalar position. Both models were compared by ANOVA.

Results
437 patients (510 ears) have been implanted with a contour advance electrode array. In 450 cases imaging data according to the selection criteria was available. 47 ears were excluded due to alterations of the cochlear structure (i.e. malformations, obliteration). In 67.2% the electrode was inserted fully in scala tympani, 18.6 in scala tympani with dislocation, 11.9% in scala vestibuli and 2% in scala vestibuli with dislocation. The fitting of the model including the position of the electrode array showed a significant better fit than the base model without scalar position.

Conclusions
Electrode position in scala tympani shows a significant beneficial effect on speech discrimination achieved post implantation. Albeit the small effect size, minimizing cochlear trauma induced by surgery is clearly of importance and the effect of electrode position relative to the cochlear structures becomes evident.

O13

Acoustic evoked potentials recording with a cochlear implant

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The first author declares having no conflict of interest. The second and third authors were students at the time of their involvement in the project, however are employees of Med-El at present.

Objectives
To develop a technical system for measuring acoustic evoked potentials, e.g. cochlear microphonics (CMs) through the cochlear implant.

Background
In electric-acoustic stimulation, patients with residual good low frequency hearing are implanted with a cochlear implant (CI) with a shorter cochlear electrode, such that the acoustic hearing is preserved. A difficulty for the surgeon is to decide how deep to insert the electrode. One possibility is to monitor acoustically evoked CMs for changes, which requires an external recording system and placing a recording electrode in close vicinity of the first turn of the cochlea.

Methods
We developped a complex triggerable acoustic stimulator which can be set up to stimulate ramped sine bursts with cyclic parameter variations such as amplitudes, frequencies, phases, pre-trigger delays and trigger number division. Using this system in combination with the Med-El clinical ART functionality, we recorded acoustic potentials from a CI/EAS user.

Results
We were able to record acoustic evoked potentials through the implant system. Variation of acoustic level, phase and frequency resulted in corresponding changes of the observed potentials.

Conclusion
Recording of acoustic potentials through the Med-El ART system is feasible, given the stimulator is capable of producing the stimuli that correspond to the measurement procedures of the ART procedure.

O14

Vestibular assessment in CI: a change of perspective

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Objectives
Importance of pre- and postoperative vestibular testing combining different measurement techniques.

Background
In the '80s, the role of preoperative vestibular testing in CI candidates was limited. Nowadays, the importance of vestibular evaluation has been altered dramatically, because 1) CI criteria changed (e.g. residual hearing) 2) modern vestibular techniques are available now.

Methods
Retrospective and prospective research is performed using conventional ENG and more recent techniques, such as v-HIT (video-Head Impulse Testing) recordings or c-VEMP (cervical-Vestibular Evoked Myogenic Potentials). Postop vestibular degradation is assessed in >500 CI patients. Pros/cons and technical constraints of different objective measurement techniques (e.g. with(out) goggles, (c)overt saccade detection, sampling rates) are evaluated for their specific parameters.

Results
Besides ENG, vHIT without goggles appeared to be quick, less invasive and more child-friendly compared to traditional ENG/VNG and is in agreement with bithermal caloric outcomes in 93% of the subjects. It detects complete uni/bilateral vestibular loss and is a tool to diagnose abnormal/absent VOR in peripheral lesions. No deviant VOR gains were found in patients with normal ENG. A sample rate of 100Hz is sufficient to capture not only overt, but even covert saccades. Regarding postop functionality, present data confirmed our previous pilot reporting postop vestibular degradation in 25% of CI patients ($p<0.05$).

Conclusions
To choose (preop) the optimal ear and evaluate (postop) vestibular functionality in case of vestibular degradation, vestibular assessment is indispensable nowadays. Clinical application of vHIT in CI candidates is relatively simple, easy and fast (< 10 minutes) and should be used in preop selection procedures, especially when ENG/VNG is laborious, e.g. in young children. Besides, to an increasing extent, conventional ENG still is of prime importance.

O15

Retrospective longitudinal assessment of balance control in adult cochlear implantation

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Abstract
What sort of vestibular deteriorations were observed before and after cochlear implantation and what are the repercussions on balance control in deafened adults?

Objectives
To assess balance control in adult cochlear implant (CI) users before and after surgery.

Methods
A retrospective cohort study of patients implanted with a cochlear implant in a tertiary care center between 2003 and 2013 was performed. Records of 358 deafened adults (mean age: 51.69 +/- 16.8 years) with unilateral or bilateral cochlear implants were analyzed. Vestibular function in each subject was assessed by recording Vestibular Ocular Response (VOR) (videonystagmography with bithermal caloric and rotatory chair test) and by computerized dynamic posturography. Medical (e.g. deafness etiology, experience with CI, uni or bilateral implantation), and demographic (e.g. gender, age at implantation) data were also recorded and analyzed.

Results
Statistical analyses showed dissociated outcomes, with a deterioration of VOR in rotatory chair tests on the one hand, and some improvement in caloric response as well as in balance control on the other hand.

Conclusions
These results suggest that improvement in low-frequency vestibular reflectivity after cochlear implantation (as assessed though caloric testing) may be related either to a reinforced vestibular compensation phenomenon or electrical cochlear stimulation. Furthermore, whenever deterioration of VOR was observed (i.e. for mid-frequency stimulation) no substantial changes in the balance control as assessed by CDP was noted. A possible role of the restored binaural auditory cue may be hypothesized.

O16

Quantification of Balance Dysfunction in Children with Cochleovestibular Loss and Cochlear Implants

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Blake Papsin - Speakers Bureau - Cochlear Americas Co.

Objectives
To quantify balance dysfunction in children with bilateral cochleovestibular loss using objective measures of stability and movement.

Background
We have shown that balance dysfunction is extremely common in children with cochleovestibular loss. Objective measurements using biomechanical methods such as motion capture and force platforms are necessary to understand how these children move and to identify targets for therapy.

Methods
Balance was assessed in 18 cochlear implant users with bilateral vestibular loss (BVL) and 18 age-matched normal hearing children using the Bruininks-Oseretsky Test (BOT-2). Light-emitting markers placed at the head and trunk were used to measure angular movements of the head and trunk segments by comparing marker position to an upright neutral stance recorded at the start of each trial. Center of

pressure (COP) variability and velocity were obtained using force platforms which measure pressure changes by location.

Results
Children with BVL fell significantly more often than normal hearing children ($p<0.001$). Greater angular deviations and variability at the head and trunk were seen in children with BVL ($p<0.05$). COP measurements revealed significantly greater variability ($p<0.0001$) and velocity ($p=0.001$) during stationary tasks. BOT-2 scores correlated significantly with COP measures ($p<0.0001$,$R=-0.701$).

Conclusions
Objective measurement of balance using biomechanical methods is possible in children. Greater angular deviations at the head and trunk and changes in COP were seen in children with BVL suggesting a greater degree of effort while attempting to maintain upright stance. These insights may permit identification of specific targets for rehabilitation and for more objective methods to assess balance function after therapy.

O17

Cochlear Implant in Normal vs. Anatomically Abnormal Cochlea

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Objective
To evaluate outcomes after cochlear implant in children with anatomical abnormal cochlea compared to normal cochlea.

Study Design
A retrospective study of 290 children from 2004 -2010 was carried out in tertiary care center. A minimum interval of follow up was two years. Children were grouped based on abnormal cochleovestibular anatomy as normal: n=240, cochlear ossificans n= 6, incomplete partition n= 18, common cavity n=3, hypoplastic cochlea n= 14, vestibular aqueduct enlargement n=9. Post of free field audiometry and speech perception outcomes were examined.

Methods
A database containing demographics(age at implant, duration of implant use, free field audiometry and speech perception score) were used for analysis. To assess the differences in outcome between different categories of cochlear anomalies linear regression analysis were performed. The significance level was set at $p< 0.05$.

Results
17% of the implanted children had anatomically abnormal cochleovestibular anatomy as detected radiologically. There was no significance difference in speech perception scores in children with anomalous cochlea compared to normal cochlea. Children with common cavity and few with hypoplastic cochlea had reduced dynamic range and were more difficult to programme despite the fact that no fewer electrodes were inserted.

Conclusion
The presence of anomalous cochleovestibular anatomy should not play a significant role in cochlear implant surgery. However, the possible outcomes and its limitations should be discussed in detail with family.

O18

Trans-Tympanic Electrically Evoked Auditory Brainstem Response (IT-EABR) - A diagnostic tool in the management of children with inner ear malformations or AN/AD Spectrum

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Abstract
Trans-Tympanic Electrically Evoked Auditory Brainstem Response (TT-EABR) – A diagnostic tool in the management of children with Inner Ear Malformations OR AN/AD Spectrum

Objectives
To evaluate the utility of preoperative Trans Tympanic EABR testing in children with inner ear malformations and AN/AD spectrum disorder prior to cochlear implantation

Methods
Ten children in the age range of two to five years with congenital inner ear malformations or AN/AD spectrum disorder were studied. Nine of the ten subjects had severe to profound SN hearing loss associated with cochlear malformations and a hypoplastic or potentially absent auditory nerve on imaging. One subject was diagnosed with AN /AD with no inner ear malformation on imaging.
All subjects underwent the complete standard battery of audiological assessment. A golf electrode was placed transtympanically in the region of the round window to provide the EABR stimulus. Response threshold, wave morphology and latency of the ABR were recorded. Subjects with a positive EABR response received multichannel cochlear implants.

Results
Three subjects with similar Audiological and radiological findings received CI on the side that had better EABR responses. Next three had one ear better on audiological assessment. Both ears were similar on radiology. They received a CI on the audiologically poorer ear with positive EABR response. One subject had a positive EABR in one ear, but the cochlea was extremely hypoplastic and thus underwent an ABI. Two subjects had no visible auditory nerve and no EABR response and hence have been scheduled for ABI. The last child diagnosed with AN/AD spectrum with no inner ear abnormality on imaging and positive EABR underwent bilateral implantation.

Conclusions
Preoperative TTEABR testing is useful in determining the candidacy for a CI or an ABI in children with cochlear nerve hypoplasia on imaging and AN/AD type spectrum. In addition to determining the choice of device and side for implantation, it facilitates the professionals in counselling the patients and providing realistic expectations on outcomes.

O19

Measuring the cochlear duct length and its effect on electrode placement and outcomes

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Objectives
To determine if cochlear duct length is a relevant factor in determining outcomes after hearing preservation surgery.

Background
Hearing preservation cochlear implantation relies upon atraumatic insertion of the electrode. Whilst it is common to utilise a single length electrode for the majority of ears, it is well known that there is variability in cochlear duct lengths within the population. This variability may result in cochleae that are more or less suited to a particular length of electrode. Insertion depth may be related to the degree of electrode trauma and therefore hearing outcomes.

Methods
56 adult patients undergoing hearing preservation cochlear implantation were reviewed. 35 patients received the Flex 31 electrode (31mm) and 21 patients received the Flex 28 electrode (28mm). Full insertion was documented through a round window approach in all patients. Preoperative high-resolution temporal bone CT scans reformatted in axial and oblique coronal planes were used to measure the basal turn of the cochlea (A value) and to measure the outer and mid-scalar lengths of the cochlear duct to 720 degrees. Postoperative plain XRs were done to determine degrees of insertion and number of electrodes within the cochlea. Pure tone average thresholds and speech discrimination at 6 months were compared between the two groups

Results
The cochlea outer wall and mid-scalar lengths are significantly correlated with the A value measured in the oblique coronal plane (R=0.7 and 0.6 respectively, $p< 0.05$). Both measures of cochlear duct lengths were highly correlated (R=0.85) and normally distributed, consistent with temporal bone studies. The Flex 28 electrode had a greater mean insertion depth of 525 degrees and 11.3 electrodes within the cochlea compared to the Flex 31 electrode with 488.29 degrees and 10.9 electrodes. The shorter Flex 28 electrode also had a greater depth of insertion in larger cochleae. In addition, for the Flex 28 electrode, CNC (consonant nucleus consonant) word scores at 6 months were higher in larger cochleae (R=0.7, $p< 0.05$) but not for the Flex 31 electrode. Effects on hearing preservation rates will be presented.

Conclusions
This study demonstrates that standard radiological software can be used to measure the cochlear duct length and that the basal cochlear diameter is a predictor of cochlear duct length. The shorter electrode paradoxically had an overall greater depth of insertion and in larger cochleae, achieved a greater insertion angle and greater speech discrimination. This may suggest postoperative migration of the longer electrode despite full insertion. Cochlear duct lengths vary between individuals and longer electrode lengths may not necessarily result in deeper insertions or better outcomes, indicating the need for individualized electrode choice.

O20

Electrophysiologic detection of scalar changing cochlea electrode arrays – a blinded study

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Introduction:
The position of the cochlea implant electrode array within the scala tympani is essential for the best audiological outcome. If the electrode array changes the scala a worse audiological benefit can be estimated. In our previous study we observed a correlation between the intracochlear position of the electrode array and a NRT ratio. A NRT-ratio was established which supports the detection of the intracochlear electrode array position. The aim of this study was to validate the electrophysiologic ratio with external radiological observations and NRT measurements.

Material and methods:
Electrophysiologic intraoperative measurements and postoperative radiological evaluation of the intracochlear electrode position of 80 patients were evalutated. All patients were implanted with a Nucleus Advance Conture electrode in the University Hospital of Freiburg. The NRT ratio was estimated for all patients blindly compared with the radiologic results and statistically evaluated.

Results:
A good correlation was seen between the radiologic results and the NRT-ratio. Scala vestibuli positions showed a similar electrophysiologic pattern as scala tympani positions.

Discussion:
For the first time we were able to show that using the NRT-ratio in a large external group of patients, is a reliable tool to support the estimation of intracochlear electrode position.

O21

Use of aided cortical assessment to check adequacy of audio processor programs of difficult to fit children

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Julie Kosaner is an employee of MEDEL Hearing Implant Compan

Objectives
To demonstrate how aided cortical assessment (ACA) can be used to objectively check appropriateness of audio processor programs of users whose MCL's can not be set objectively.

Background
Objective fitting methods are preferred especially for children. 15-20% of children's MCL's can not be set using objective eSRT fitting method.CI users may have middle ear problems or refuse to have probe placed,Subjective fitting methods need to be used. The clinician cannot be sure of the preciseness of the program. ACA, checking P1 responses to speech tokens /M/,/G/,/T/ representing low, middle and high frequencies, presented at 55 dBSPL, can provide objective affirmation of appropriateness of provided program.

Methods
10 children implanted with a MED-EL CI who could not be fit using eSRT method underwent ACA within one week of switch on and subsequently at 1,2 and 3 months post switch on. The HearLab by Frye was used to make these measures. Modifications to programs were made when lack of P1 response was encountered. P1 responses and P1 latencies were analyzed at each test interval.

Results
CI users tended to have P1 responses to all speech tokens with latencies within the reference range by 3 months post switch on. Modifications usually resulted in improved cortical responses.

Conclusions
Inadequate cortical responses can provide clinicians with information on which to base modifications to audio processor programs ensuring users have adequate access to speech.

O22

Can we strengthen brainstem pathways from the deprived ear after unilateral cochlear implant use in children?

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Objective
We aimed to determine whether the auditory brainstem pathways from the newly cochlear implanted ear could be strengthened by removing the first implant for a period of time during the day.

Method
Thirty-four children received their first cochlear implant at 3.6±2.2 years of age and their second implant 9.6±3.2 years later in the opposite ear. The children were asked to remove their first device and use only the newly activated implant (aural patching) for 0, 2-4 or 8 hours per day (random assignment) beginning at activation of the second implant. Brainstem responses were evoked by each cochlear implant immediately after activation of the new implant and after 9 months of aural “patching”. The duration of daily “patching” was documented by the parents and also monitored by telephone interview.

Results
Wave eV latency in responses evoked by the newly implanted ear decreased over the first 9 months of use. Nonetheless, eV latency in these responses remained delayed relative to wave eV evoked by the implant in the more experienced ear. The persistent asymmetry in brainstem latencies was not correlated with duration per day or frequency per week of “patching”.

Conclusion
Activity driven brainstem development occurs despite unilateral deprivation. This development does not resolve asymmetries in function along the bilateral auditory pathways over the first 9 months of bilateral implant use and is not enhanced by daily use of the second device alone.

O23

Deconvolution of the spread of excitation curves measured in cochlear implants

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Objectives
Find the origin of the asymmetry of the objective spread of neural excitation (SOE) curves recorded by forward masking.

Background
It is observed that along the electrode array the SOE is asymmetric, with wider spread apically. There are several thoughts about the origin of this asymmetry. However, the SOE, measured by forward masking, can be seen as a convolution of the neural responses evoked by the masker and the probe. Then the asymmetry could be a consequence of the convolution of the more narrow neural responses at the basal side and the wider responses at the apical side.

Methods
SOE curves measured in patients were compared with modelled SOE curves. In 10 patients the SOE were recorded on 14 electrode contacts. A set of modelled SOE curves was created by convolving theoretical neural responses. These neural responses consist of an increasing exponential followed by a

plateau phase and a decreasing exponential. The modelled curves were fitted to the patient data with a minimisation routine.

Results
A first approach by using a model with symmetric neural responses shows a good approximation of SOE curve measured in a patient. It also shows that that the plateau phase becomes smaller apically and it includes the asymmetry at the apical side of the SOE curve.

Conclusions
The asymmetric SOE curve can be predicted by the convolution of symmetric neural responses, whereby the theoretical responses are more narrow apically.

O24

A new modified (E)ASSR paradigm for simultaneous electrophysiological recording and assessment of psychophysical performance.

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The work was supported by MED-EL, Innsbruck

Pseudo-(E)ASSR: Evaluation of simultaneous electrophysiological recording and assessment of psychophysical performancePseudo-(E)ASSR: Evaluation of simultaneous electrophysiological recording and assessment of psychophysical performance

Objectives
In order to substitute psychophysical tests in cochlear implant subjects by an objective measure EASSR may be a good candidate. Therefore, in a first step EASSR and psychophysics have to be recorded in one measurement to analyze their correlation. As the measurement of EASSR is a difficult task we first developed and evaluated a modified auditory steady state response paradigm which combines electrophysiological recording and psychophysical discrimination tasks by jitter (Pseudo-ASSR). In order to analyze the recorded stream, stimulus beginning and changes in the stream has to be detected reliably.

Background
Psychophysical measurements are typically accompanied by a high variability in performance; whereas in electrophysiological measurements noise is mostly due to peculiarities in the measurement environment and can be substantially reduced. Provided a high correlation between both entities the results of ASSR measurements may substitute measurements in e.g. pitch discrimination tasks in a further step.

Methods
In order to change simultaneously ASSR and psychophysical performance the saliency of the modulation in a sinusoidal amplitude modulated signal has to be modified. For this, the duration of complete modulation cycles were jittered. The stronger the jitter the lower is the ASSR signal and pitch saliency. Detection algorithms were evaluated in recordings with an artificial ear and a human subject.

Results
As the exact timing of the stimulus changes related to the recording window is unknown, it is only possible to analyze the recorded EEG signal in respect to signatures generated by the stimulus variations. Tests showed that the beginning of the stimulus as well as the change in the stimulus could be reliably identified in the EEG signal with the developed detection algorithms.

Conclusions
The pretests show that it is possible to simultaneously record electrophysiological responses and psychophysical measures and that it is possible to analyze the EEG signal for its signatures in stimulus changes. Therefore, implementing the same paradigm for EASSR in cochlear implants seems promising.

O25

Optimization of a Spectral Contrast Enhancement Algorithm for Cochlear Implants based on an Individualized Electrode-Nerve-Interface Model

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Background
Considerable variation in speech intelligibility outcomes when comparing two sound coding strategies has been seen in many clinical studies. One possible reason that might explain this variability is their individual electrode nerve interface which can impact the spectral resolution they can achieve. Spectral resolution has been reported to be closely related to vowel/consonant recognition in cochlear implant (CI) listeners . One measure of spectral resolution is the spectral modulation threshold (SMT), which is defined as the smallest detectable spectral contrast in the spectral ripple stimulus.

Methods
In this study we hypothesized that an algorithm that improves SMT might also be able to improve vowel recognition, and consequently produce an improvement in speech understanding. With this purpose we implemented an algorithm, termed Spectral Contrast Enhancer (SCE) that is able to emphasize peaks with respect to valleys in the audio spectrum. This algorithm can be configured with a single parameter: the amount of spectral contrast enhancement entitled “SCE factor”. Additionally, we would like to investigate whether the “SCE factor” can be individualized to each CI user. With this purpose we developed a peripheral model of cochlear implant neural activity. The model has been individualized to the electrode nerve characteristics of each study participant, for example using information about their cochlear size, electrode position, impedance matrix values and monopolar and bipolar thresholds. Next, the parameters of the model were adjusted using a pattern recognition algorithm to match the SMT of each CI user. Finally, the model was used to predict the performance produced by the SCE algorithm with two different “SCE factors” in a vowel identification task.

Results
In 7 CI users the new algorithm has been evaluated using a SMT task and a vowel identification task. Audio signals were processed with and without the SCE algorithm and presented to the CI users through the nucleus research interface at an equivalent level of 65 dB SPL. The task was performed for SCE factors of 1 (no enhancement), 3 and 5.

6 out of 7 CI users obtained an improvement in the SMT task corresponding to their improvement in vowel identification scores with an SCE factor of either 3 or 5. The mean improvement obtained by the SCE algorithm for the SMT and the vowel/consonant identification task were 1.9 dB and 5% respectively. The individualized cochlear implant model was able to predict the optimal “SCE factor” for the 7 study participants.

O26

The TPACE strategy: Finding an objective measure for the prediction of the optimal masking value

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No conflict(s) of interest.

Objective
Finding an objective measure for the prediction of the optimal masking value

Background
The novel CI coding strategy TPACE extends the original PACE (Psychoacoustic Advanced Combination Encoder) algorithm, the research version of the clinically established MP3000 coding strategy, with a temporal masking model. The strength of the exponentially decaying temporal masking effect is described by the temporal masking half-life T½. This time constant gives the time after which the effect of temporal masking has decreased to half the amount of the preceding simultaneous masking.

Methods
Two acute experiments using the NIC streaming environment were performed. In the first experiment, twelve subjects were tested with HSM sentences in noise in three conditions: TPACE using T½ of 0.5, 1.1 and PACE as a baseline. In a second experiment, two additional T½ values (0.4 and 0.8 ms) as well as the measurement of the ECAP recovery functions were included into the experiment. Up to date, four subjects were measured within the second experiment.

Results
A statistically significant increase in performance was found in the first experiment for the condition with T½ = 0.5 ms. Preliminary results of the second experiment show an improvement of 11 to 23 % for an optimal T½ between 0.4 and 1.1 ms compared to the original PACE algorithm. No correlation between the optimal T½ and the recovery function was observed within the preliminary dataset.

Conclusions
It seems that the consideration of short-acting temporal masking does improve speech intelligibility in cochlear implant subjects. We hope to be able to predict optimal masking values from ECAP recovery functions.

O27

Electrically Evoked Compound Action Potentials Using Novel Stimulation: Opportunities and Challenges

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All authors are employed by Cochlear Ltd.

Objectives
To describe opportunities and challenges of using novel waveshapes and multi-polar stimulation for Electrically Evoked Compound Action Potentials (ECAPs).

Background

Forward masking of biphasic current pulses is a widely used means of obtaining ECAPs. It measures the compound neural response to the probe alone, the masker alone, and the masked probe. Interpretation of the subtraction of these measurements assumes that the masking of the probe is entirely suppressive on all nerve fibers and does not introduce any sub-threshold facilitation. Other techniques have their own limitations. As such these techniques may provide inaccurate information about the state of the neurons at each location in the cochlea. Stimulation using multi-polar electrode configurations and novel waveshapes may allow better neural diagnostic information to be obtained.

Methods
The subjects were adult users of an experimental cochlear prosthesis that contained no implanted electronic components. Wires from all electrodes were terminated directly to a connector housed in a percutaneous titanium pedestal mounted to the skull behind the ear. Through the percutaneous device we could present 24 simultaneous electrode currents with high precision using bench-top current sources and also record responses through isolated amplifiers.

Results
Neural responses to novel stimulation were obtained without the need for a masker and showed many of the same characteristics as those measured with more traditional measures. Comparisons of the patterns of activation are under study.

Conclusions
Novel waveshapes using multi-polar stimulation present opportunities for improved diagnostics. One challenge is how to interpret these results in comparison to previous approaches.

O28

Desynchronized discharges of auditory nerve fibers in electric stimulations: mechanisms and consequences.

Jonathan Laudanski (Oticon Medical)

Objective:
Explore extensively the different parameters leading to desynchronized actions potentials and their relation to sound coding in interleaved-pulses strategies.

Background:
High pulse rate are known to desynchronize the activity of auditory nerve fibers helping in providing an increased dynamic range of electrical stimulation. This effect is attributed to sodium inactivation during the relative refractory period. In contrast to the single channel case, a description of desynchronizing effects is given at the population level for different stimulation strategies.

Methods:
A numerical model of nerve fibers with stochastic ionic channels is used to model response to electric pulse trains. The model is based on Fox & Lu's system size expansion of conductance noise. We simulate neural discharges in response to speech stimuli from different stimulation rates and interleaved-pulses strategies. Using a reverse analysis, the firing efficiency and jitter contributions of electrical pulses preceding each discharge are assessed.

Results:
High frequency pulse trains are shown to desynchronize responses in this new model in a similar way to classical studies. The reverse analysis demonstrates that discharge variability depends on an "effective" pulse rate. Because of current spread from neighboring electrodes, the effective pulse rate lowers the minimal stimulation rate necessary to elicit desynchronizing effects. The silent epochs in N-of-M coding strategies are shown to affect strongly the synchrony of the population.

Conclusion:

This works provides a basis for lower rate stimulation strategies which would decrease power consumption while maintaining the benefits of desynchronizing pulse-trains.

O29

Evaluating Focused Stimulation Thresholds In The Context Of A Cochlear Impedance Model

Steven Bierer (University of Washington) Julie Bierer (University of Washington)

Objectives
One major goal of our laboratory is to identify implant channels that transmit information poorly to the listener. Here, we compare three distinct measures: psychophysical thresholds, electrical field imaging (EFI), and computed tomography (CT) imaging.

Background
Previous research suggests that channels with high thresholds, when measured with a focused electrode configuration, have a reduced ability to transmit spatial, temporal, and intensity cues. Such channels are likely affected by a degraded electrode-neuron interface, but the potential contributing factors are not well understood.

Methods
Thresholds to tripolar or quadrupolar stimulation were obtained on all channels using a 2-interval forced-choice or Bekesy-style tracking method. CT images were obtained to determine placement of individual electrodes within the cochlea. EFI data was analyzed to estimate parameters of an impedance network modeling the cochlear tissues.

Results
For five of six subjects, transversal impedances - representing the leakage of current out of the cochlea - had a significant positive correlation with the distance of each electrode from the cochlear inner wall. Threshold did not consistently correlate with distance or impedance within subjects. However, across the same five subjects, there was a trend toward higher thresholds with higher impedances, particularly for apical electrodes. Interestingly, the remaining subject had particularly high thresholds and poor speech perception. Implications of the observed impedance variations across the cochlea with respect to the CT imaging data will be discussed.

Conclusions
The results suggest that EFI can be used as a complement to focused thresholds to further understanding of channel-to-channel perceptual variability.

O30

Ecap Recording during Cochlear Implant Surgery

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The research has been supported by Cochlear Deutschland GmbH

Objectives
The objective of this study is to assess the accuracy of threshold recording of the electrically evoked compound action potentials (ECAP) during cochlear implant (CI) surgery and their applicability for parameter estimations at 1.fit.The objective of this study is to assess the accuracy of threshold recording

of the electrically evoked compound action potentials (ECAP) during cochlear implant (CI) surgery and their applicability for parameter estimations at 1.fit.

Background
During CI surgery objective measures like the recording of electrode impedances, electrically evoked stapedius reflex and ECAP thresholds are helpful to ensure CI system integrity and excitability of the VIII nerve, as well as gaining information about the position of the electrode array. Possibly they can be valuable for parameter estimations to assist 1.fitting of the speech-processor.

Methods
In patients with nucleus CI24RE implants repeatability was used as measure of accuracy and reproducibility of thresholds measured during surgery and at the time of 1.fit to estimate the value of intra surgery ECAP thresholds (TNRT) at time of 1.fit. Repeated measures of TNRT using the AutoNRT algorithm in CustomSoundEP(CSEP-AutoNRT) and the remote assistant CR220 were performed during surgery. CSEP-AutoNRT was used repeatedly at time of 1.fit and during the following time of system use.

Results
For the intra surgery TNRT-recordings mean absolute test-retest differences were 5±6su with CSEP and 4±6su with CR220. The mean absolute difference between TNRT recorded with CSEP and CR220 was 6±6su. The long term stability was in the same range of reproducibility (6±6su). However, there was a significant difference between the recordings during surgery and at 1. Fit (16±12su).

Both methods of intra surgery recordings showed comparable accuracy of measurements. Care has to be taken if data of intra surgery threshold recordings are used as estimators for parameters during 1.fit.

O31

Automated ECAP classification

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Advanced Bionics internal study.

Abstract
Enter the abstract here. Word count does not include title and authors/institutions.

Objectives
Define criteria to objectively classify ECAP signals as containing or not a true neural response.

Background
Electrically-evoked compound action potentials (ECAPs) are commonly used in clinical routine for assessing the auditory nerve functionality. Automated ECAP algorithms aim to deliver regular ECAP function outcome without the need of parameterization of the stimulation and recording settings. These automated ECAP-functions decide on which current-unit to set next depending on ECAP classification as containing or not a neural response, until a satisfactory ECAP-threshold is obtained (Glassman & Hughes, 2013). ECAP classification is a critical step in automated ECAP functions: it should be made as accurate as possible.

Methods

Comparison was made between automatic and visual rating of a retrospective dataset of 18,375 ECAP traces obtained with RSPOM using Smart-NRI, Recovery and Spread-of-Excitation. Both criteria retained for automatic ECAP classification was the voltage magnitude of N1-P1 and the signal-to-noise ratio between the section where the neural response was expected and the last 42 samples where neither neural response nor artifact was expected.

Results
Good ECAP classification was achieved using the combination of +5 dB-SNR and 50 µV: it produced the best compromise between high true-positives and –negatives and reasonably low level of false-positives and –negatives. This was particularly good with Recovery / Spread of Excitation.

Conclusions
Objective classification of ECAPs is possible using a combination of voltage and noise thresholds, this is implemented in Express-NRI functionality of VOLTA.

O32

A novel ECAP recording paradigm to acquire fine-grain growth functions

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No conflict(s) of interest.

Objectives
We want to extend the recording paradigm routinely performed to acquire evoked compound action potential (ECAP) amplitude growth functions (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.

Background
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 AGF, these measurements are normally performed for 5 to 10 different stimulation levels.

Methods
We present a recording paradigm 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 10 MED-EL CI users using the new proposed ECAP recording paradigm as well as the above described standard clinical procedure. 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. Furthermore the fine-structure of the AGF is analyzed in single cases applying an extended sigmoidal model of the AGF.

Conclusions
Beside a more robust determination of the eCAP threshold, the proposed quasi-continuous stimulation paradigm can also reveal the fine-structure in the amplitude growth function.

O33

Effects of Stimulus Polarity and Artifact Cancellation Method on ECAP Responses

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This research was supported by grant # R01 DC009595, NIH, NIDCD

Objectives
The goal of this study was to examine the combined effects of stimulus polarity and artifact reduction method on ECAP responses.

Background
Animal work suggests that cathodic stimulation is most effective at eliciting auditory-nerve responses with electrical stimulation; however, more recent studies with humans suggest that anodic stimulation is more effective. Our previous research comparing ECAP artifact reduction methods indicates larger amplitudes and lower thresholds with cathodic-leading forward masking (CathFM) than with alternating polarity (AltPol). One interpretation of this result is that the anodic-leading phase used with AltPol elicits a less excitatory response (in contrast to recent human studies), which when averaged with responses to cathodic-leading stimuli, results in smaller amplitudes. Another interpretation is that the latencies of the responses to anodic- and cathodic-leading pulses differ, which when averaged together, result in smaller amplitudes than for either polarity alone. The purpose of this study was to separate the effects of stimulus polarity and artifact reduction to determine the relative effects of each.

Methods
ECAP growth functions were obtained using: (1) CathFM, (2) FM with anodic-leading pulses (AnodFM), and (3) AltPol. Symmetrical biphasic pulses were used for all conditions. Threshold, amplitude, and latency were compared across methods.

Results
Preliminary results show larger amplitudes for AnodFM than for CathFM, with similar thresholds and latencies. AltPol produced smaller amplitudes, higher thresholds, and longer N1 latency than for either FM method.

Conclusions
AltPol results do not appear to be the result of excitation effectiveness or latency differences between polarities.

O34

NRT based fitting using profile scaling

Saji Maruthurkkara (Cochlear Ltd)

Employed my implant manufacturer

Background
NRT based programming is now used widely in clinical practice. A few different programming methods using ECAP profiles have been in routine clinical use. These NRT based fitting methods are based on the fact that (1) ECAP thresholds have shown to have a modest correlation with T and C levels, (2) T and C

levels can be reasonably predicted by applying the shifts to the ECAP profiles and (3) The correlation can be further improved by applying tilts to the profile based on feedback from the recipient. It was shown that a Profile scaling correction can further improve the correlation between ECAP thresholds and T and C levels. Remote Assistant Fitting (RAF) implements an NRT based fitting method which utilizes the profile scaling corrections. The aim of this study was to evaluate the correlation of the MAP levels and speech perception performance with remote assistant fitting and conventional fitting.

Methods
New programs were created using RAF and 13 adult cochlear implant recipients were asked to use RAF to make adjustments to their program in real world environments for two weeks. In this double blind, randomized study, speech perception testing and take home use of the RAF program was evaluated compared to the behavioral programs created by expert clinicians.

Results
The C levels obtained with RAF had a very high correlation (r = 0.92) with the Custom Sound levels. Performance results of group results show no significant differences for CNC words at soft levels (50dBA). Nor were there significant differences for Austin sentences in noise. All recipients adjusted their programs during the take home use and ended up making some level of adjustments to their programs.
Conclusions: The performance results for the group are not inferior to conventional fitting, opening the possibility for new models of clinical care. The addition of live adjustments and profile scaling correction helps improve the correlation of the MAP levels.

O35

Myographic Recording of the Electrically Elicited Stapedius Reflex

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No conflicts.

Abstract
MYOGRAPHIC RECORDING OF THE ELECTRICALLY ELICITED STAPEDIUS REFLEX
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Background and Objectives
It is well-known that the electrically elicited stapedius reflex threshold (ESRT) correlates very high with the maximum comfortable level (C- or M-Level) and thus, is a viable tool to set upper stimulation limits in the fitting of cochlear implant subjects. Therefore, in many cochlear implant programs, ESRT is obtained intraoperatively by observing the contraction of the muscle. Postoperative evaluations of the muscle response by impedance bridge is very time consuming and in many cases not possible due to middle ear disturbances in the contralateral ear. The aim of this study was to investigate the feasibility of a myographic recording with an intramuscular micro needle electrode.

Methods
Different recording electrodes were developed and optimized to fit the placing requirements and penetrate the stapedius muscle. For eliciting the reflex a dual biphasic rectangular stimuli was used. Recordings were performed with a Nicolet Quest recording unit.

Results
With this setting, up to date in more than 20 subjects tested ESRT could be obtained on at least one

electrode. When compared to the visually determined thresholds and later M-level, differences were not statistically significant.

Conclusions
This study demonstrates that myographic signals can reliably be recorded by an electrode from the stapedius muscle. However, more work is needed to optimize signal strength by recording electrode enhancement and stimulus optimization. A further step could be to include this measurement method into a cochlear implant device. Then, ESRT – like ECAP measurements today - could be obtained postoperatively at any given time and would be an excellent parameter for fitting as well as long term observation of the thresholds of cochlear implant subjects.

O36

Intraoperative Measurement in Bonebridge Surgery

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Conflict of interest: none

ObjectivesTo investigate the possibility of using a modified reverse transfer function measurement intraoperatively during the surgery of a new transcutaneous bone conduction hearing implant to evaluate the status of the device.

MethodsTests were performed on a cadaver skull (preclinically) and two conductive hearing loss patients implanted with a new transcutaneous bone conduction implant. During intraoperative activation, the reverse transfer function was measured using a microphone attached perpendicularly and directly to the skin in the middle section of the forehead.

Results
The reverse transfer function could be measured for all frequencies from 500 to 6000 Hz.

ConclusionsThe usage of an intraoperative reverse transfer function measurement may be a good method to verify the mechanical coupling of the bone conduction floating mass transducer and to test the functional integrity of the implant in an objective way.

O37

Approaches to eliminate overstimulation in children after cochlear implantation

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Background
The objective of cochlear implant fitting is to optimize the parameters of electric stimulation to achieve the best possible speech perception. When stimulation levels are set too low, hearing sensations are limited

what pushes fitting specialists to increase delivered stimuli. But when stimulation levels are set too high, sound quality can be distorted lowering hearing benefits. The aim of the study was to assess via objective methods and questionnaires if children undergoing routine fitting could be affected by overstimulation

Methods
The study group consisted of 27 children implanted with Cochlear (14 patients) and Med-El (13 patients) devices. All patients were tested after nine months after first fitting during scheduled follow-up visit. All of them had acoustically elicited stapedius muscle reflex threshold measurement performed. Questionnaires on loudness perception were distributed among children's parents to assess subjective program loudness in everyday use and then collected during mentioned visit.

Results
Results from surveys indicate that there is no direct correlation between acoustically evoked stapedius muscle reflex threshold and questionnaire responses, but almost 70% of children with "very loud" answers in questionnaire showed acoustically evoked stapedius muscle reflex threshold equal or lower than 70dB HL.

Conclusions
By adding new objective and subjective tests to the standard test battery it is possible to identify children suspected of overstimulation. Additionally it seems that parents sometimes are too conservative while describing children hearing sensations.

O38

Conventional and remote intraoperative NRT measurement

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No real or apparent conflict(s) of interest.

Background
The neural response telemetry(NRT) in the Nucleus system measures the action potential of the cochlear nerve with the electrical stimulation. Neural response telemetry measurements have been a valuable tool to check the integrity of the cochlear implant and neural reserve.The Nucleus CI system also has an automated system to determine the threshold level, known as AutoNRT™ . AutoNRT™ which is measured with the conventional programming system can also be obtained through CR 220 intraoperative remote assistant.

Objectives
In this study the aim is to establish the reliability measurement of Evoked Compound Action Potential (ECAP) thresholds obtained through the AutoNRT™ system and CR 220 intraoperative remote assistant.Another area of **interest** was to compare the intraoperative NRT thresholds with the post operative ones.

Method
19 patients who received a Nucleus CI24RE,CI422 cochlear implant for treatment of severe to profound hearing loss were included in the study.The age range of the patients is 13 months to 15 years.
NRT thresholds are measured intraoperatively on all operational electrodes through conventional AutoNRT™ system and CR 220 intraoperative remote assistant.

Results
Auto NRT thresholds obtained in two systems were compared. Results for the NRT thresholds revealed no statistically significant differences between the traditional and remote conditions for all electrodes

tested and also when the NRT thresholds were compared on electrode basis.
Intraoperative NRT thresholds were also compared with the postoperative AutoNRT thresholds.The intraoperative NRT thresholds obtained with the two measurement systems were found significantly higher than the postoperative NRT thresholds

Conclusion
CR220 intraoperative remote assistant provides reliable NRT thresholds. There were no statistically significant difference between NRT thresholds obtained through CR220 and those obtained with the traditional AutoNRT method.

O39

Cortical Correlates of Spectral and Temporal Processing Cochlear Implant Subjects Using the Acoustic Change Complex

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Background
Previous psychoacoustic work has shown that temporal processing in the form of amplitude modulation (AM) detection ability is related to speech perception in CI users. Additionally, spectral processing ability has been implicated in the ability to understand speech in noise. The current study employs temporal (AM) and spectral stimuli in a cortical evoked potential paradigm known to elicit the acoustic change complex (ACC). The ACC is an evoked response (N1/P2) in response to a "change" in acoustic properties in contrast to an onset type stimulus/response. We hypothesized that the ACC to temporal and spectral "change" in an ongoing stimulus is an ecologically valid stimulus and cortical responses would be related to speech perception outcome in CI users.

Methods
Temporal change stimuli consisted of continuous white noise with occasional AM lasting one second. The AM consisted of 4, 40, 100, and 300 Hz. Spectral change stimuli consisted of a continuous pure tone (250 Hz and 4000 Hz) with occasional spectral changes lasting 400 ms. The degree of spectral change corresponded to approximately 2 and 3 centre CI channel band widths away from the base tone with an additional small spectral change within the same CI channel. All stimuli were presented acoustically in free field while the CI subject used their everyday CI setting. Subjects passively watched a closed-caption movie while 64 channels of electroencephalograic activity was measured.

Results
Temporal ACC: Most subjects (n=10) showed N1 responses especially to low modulation rates. As the AM rate became greater, N1 responses diminished. No significant relationships were observed between N1 amplitude and speech perception scores. However, with the 40 Hz AM change stimulus, a significant relationship was seen with speech perception and N1 latency such that the higher the speech perception score, the earlier the N1 response. Paradoxically, with the 100 Hz AM change stimulus, earlier N1s were observed in CI users with poor speech perception.
Spectral ACC: Most subjects (n=4) showed robust N1 responses. Spectral ACC responses were greater in magnitude compared to temporal ACCs. The relationship between spectral ACC and speech perception is still being explored.

Conclusions
The preliminary data suggest that both 40 and 100 Hz AM stimuli show promise as an objective tool to assess speech perception. The direct relationship with speech perception and 40 Hz AM suggest that

good users have the ability to encode and process the AM stimulus that is part of the normal speech envelope. The paradoxical “better” responses with 100 Hz AM may reflect a non-specific “detection” process rather than useful cortical processing needed for discrimination. Spectral ACC data will be presented as well preliminary data in pediatric CI users.

O40

Cortical voice processing in cochlear-implanted children: an electrophysiological study

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Objectives

To investigate human voice processing with cortical auditory evoked potentials (AEPs) in cochlear-implanted (CI) children.

Background
In children with prelingual deafness, the use of cochlear implants can restore both auditory input to the auditory cortex and the ability to acquire spoken language. Language development is strongly intertwined with voice perception. The aim of this electrophysiological study was to investigate human voice processing with cortical auditory evoked potentials (AEPs) in cochlear-implanted (CI) children.

Methods
Eight CI children (2 males, 6 females) aged 4-12 years (mean age: 8 years), fitted with a unilateral cochlear implant (CI group) for congenital sensorineural hearing loss were included in this study. All of them had good auditory and language performance. They were investigated with cortical AEPs and compared with 8 normal-hearing age-matched controls (mean: 8.5 year-old). The electroencephalogram were recording from 28 Ag-AgCl cup electrodes. The auditory stimuli were vocal and non-vocal sounds delivered in free field. The vocal non-speech sounds were produced by a large number of speakers of both genders and different ages. Non-vocal sounds consisted of sounds from a wide variety of sources, including human environments, musical instruments, and nature. Independent component analysis was used to minimize the cochlear implant artifact in cortical AEPs.

Results
Fronto-temporal positivity to voice was found in normal-hearing children with a significant effect in the 140-240 ms latency range. In the CI children group, we found a positive response to voice in the 170-250 ms latency range with a more diffuse and anterior distribution than in the normal-hearing children. Fronto-central responses (P1-N2-N4 waves) did not differ between the 2 groups.

Conclusions
Response to voice was recorded in normal-hearing and CI children. The topography and latency of response to voice differed from that recorded in normal-hearing children. This finding argued for cortical voice processing reorganization in congenitally deaf children fitted with a cochlear implant.

O41

Audiovisual integration in the auditory cortex following cochlear implantation measured by near-infrared spectroscopy

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This study has been partly been funded by Cochlear Corporation

Objectives
To determine the feasibility of recording brain activity of postlingually deaf individuals after cochlear implantation with near-infrared spectroscopy, and to compare the cross-sensory activation of auditory cortex of implanted and normal-hearing individuals with near-infrared spectroscopy.

Background
Early hearing loss disrupts normal development of the auditory system. The major question remains how restoration of peripheral hearing by implanting a cochlear implant (CI) would affect central auditory processing. Traditional neuroimaging methods such as fMRI, MEG and EEG are impractical to study such processing because of artifacts induced by the CI, while PET has the disadvantage of being a highly invasive technique. Functional near-infrared spectroscopy (NIRS) does not suffer from these drawbacks.

Methods
We recorded changes in oxy- and deoxyhemoglobin concentrations ([OHb] and [HHb]) above auditory cortex for 40 normal-hearing subjects and 10 CI-users, for three types of stimuli: auditory, visual and audiovisual speech segments of a video recording of a female Dutch speaker.

Results
Many normal-hearing subjects had no discernible response. For those that did, an increase in [OHb] was observed during sound presentation, with a smaller increase during visual presentation. This was also true for CI-users. The bimodal stimuli elicited a sub-additive effect.

Conclusions
As the NIRS technique is not as standard and as well-documented as other neuroimaging techniques, a high success rate in eliciting a response from any single subject is low. Despite this limitation, comparison between sensory conditions (or sound levels, frequencies, etc.) is a promising technique to differentially measure hemodynamic activity in the impaired central auditory system.

O42

Changes in alpha oscillations compared to pupil dilation to capture listening effort in cochlear implant users; an initial study

Isabelle Boisvert (Macquarie University) Catherine McMahon (Macquarie University) Peter DeLissa (Macquarie University) Kelly Miles (Macquarie University)

Objectives
This study compares the onset and magnitude of two objective measures of listening effort during speech recognition tasks of increasing difficulty performed by adults with cochlear implants.

Background
Individuals with hearing loss often report the increased “listening effort” they invest in their daily communication. While this may negatively affect an individual’s participation in communicative engagements at work and at home, it is poorly understood and not commonly evaluated in audiology clinics. Increased effort (or a greater investment of cognitive resources such as attention and working memory) may enhance speech recognition performance, but the amount of listening effort for the same task probably varies across individuals. It has been suggested that changes in oscillation power of alpha band measured with EEG, may be a valuable tool to evaluate this increase in cognitive resources expended during difficult speech recognition tasks. Increased task difficulty during speech recognition has also been related to greater pupil dilation (Zekveld et al, 2012).

Methods
This initial study with 6 adult cochlear implant users is informed by our studies using similar methodologies with normal hearing adults. Alpha power was measured using a 26-channel EEG and pupil dilation using eye-tracking during a randomised sentence recognition task in quiet and in noise (+10dB SNR). Electrical artefacts produced by the cochlear implant were minimised using independent component analysis.

Results
Preliminary analysis of the data suggests that increases in speech recognition task difficulty are related to both an increase in alpha power in the parietal region of the cortex and an increase in pupil dilation.

Conclusions
Alpha oscillations and pupil dilation are two objective measures that appear related to listening effort. The relationship between the two measures will be discussed. The findings will have implications for assessing listening effort in a clinical setting in combination with standard speech perception tasks.

O43

A Novel Technique for Evaluating Residual Hearing in Cochlear Implant Recipients

Kanthaiah Koka (Advanced Bionics) Smita Agrawal (Advanced Bionics) Leonid Litvak (Advanced Bionics)

Authors are full time employed with Advanced Bionics

Objectives
(1) To develop a technique for measuring cochlear potentials via the cochlear implant (CI) system.
(2) To evaluate and monitor residual hearing in the implanted ear.

Background
The increased incidence of acoustic hearing in CI candidates has necessitated the need for intra- and postoperative evaluation of residual hearing. Electrocochleographic (ECoG) potentials offer a means to

do so. These signals have also been found to be correlated with CI recipients' performance outcomes.

Methods
We developed a technique to post-operatively measure ECoG potentials using Advanced Bionics intra-cochlear electrodes. In the present study, (1) acoustic stimuli presentation was synchronized with intra-cochlear recording, (2) ECoG potentials were measured and compared across different intracochlear contacts, and (3) artifacts were differentiated from ECoG potentials at higher stimulus levels via bench experiments.

Results
ECoG responses were successfully measured via the new method. Response amplitudes varied as a function of input frequency and intra-cochlear contact location. Inter-subject variability was also observed. In addition to input frequency components, responses showed presence of distortion products, possibly indicating neural components. Phase differences were seen at different locations across the cochlea. During bench testing, ECoG responses were not measured even with stimulus levels as high as 100 dB HL hence validating the technique to differentiate artifacts from ECoG signals measured in CI recipients.

Conclusions
Post-operative cochlear potentials can be measured using the new technique in recipients with AB's Advantage implant. Intracochlear ECoG recordings could provide information useful for optimizing CI performance.

O44

Measuring listening effort in CI listeners using pupil dilation

Matthew Winn (University of Wisconsin-Madison) Ruth Litovsky (University of Wisconsin-Madison)

Objectives
We aim to use pupil dilation to objectively measure listening effort in individuals with cochlear implants (CIs), to identify improvements that go undetected by some traditional analyses, and to recognize the importance of effort in the daily lives of patients. We explored bilateral benefit and improved spectral resolution resulting from increased electrode spacing.

Background
Patients often report benefit from new CI technologies or from bilateral implantation without showing corresponding changes in speech perception scores. In cases where speech intelligibility does not clearly reveal benefits, listening effort can be an ideal outcome measure. As people with hearing impairment suffer considerable consequences from elevated listening effort, this approach could have impact on outcomes assessment and long-term quality of life.

Methods
Pupil dilation was measured in a sentence recognition task where bilateral CI listeners used their 1) basic bilateral clinical map, 2) left ear, 3) right ear, 4) dichotic interleaved map (odd-index and even-index channels activated in opposite ears). Pupil dilation in each trial was modeled using growth curve analysis.

Results
Nearly all listeners exerted less effort using two implants compared to one, even when compared to their better ear. Half of the listeners showed improvement from dichotic interleaved channels, and half showed decline, consistent with their performance on a behavioral test of spectral resolution, and generally consistent with their self-reported perceived sound quality.

Conclusions
Pupil dilation is an objective and sensitive measure of listening effort that can potentially evaluate aspects of CI listening that have historically been difficult to quantify.

O45

Cochlear Implant Performance and Electrically-Evoked Auditory Brain-Stem Response Characteristics

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Objectives: To examine the relationships between the electrically evoked auditory brainstem responses (EABRs) in multichannel cochlear implant (CI) users and speech recognition performances.

Background: The individual performance varies greatly across CI subjects and may be partly related to the degree of neural survival throughout the auditory pathway measured by EABRs.

Methods: EABRs were measured in 18 patients implanted with a Digisonic SP (Neurelec®) cochlear implant. The stimuli were delivered to 4 electrodes distributed along the cochlea at 70 % of the dynamic range. EABRs were measured for each electrode alone and with a simultaneous stimulation. Speech recognition performances without lip-reading were tested using Vowel-Consonant-Vowel (VCV) test.

Results: A significant correlations between speech recognition performance and wave III-V latency interval of EABR was found. We have also observed :i) greater amplitude and reproducibility of waves III and V with apical electrodes; ii) shorter latencies in simultaneous stimulation.

Conclusions: EABRs can provide a reliable and objective assessment of functional results in CI patients. This specific testing could contribute to the evaluation of functional prognosis and serve to guide the rehabilitation.

O46

The effect of device use on brainstem maturation in sequential bilateral cochlear implantation in children

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Objectives
To determine whether the electrically evoked auditory brainstem responses (EABRs) evoked by the CI2 are comparable with those evoked by the CI1 after 5-6 years of BiCI use. Device use and speech recognition results per implanted ear were obtained.

Methods
A cohort of 30 children with BiCIs implanted sequentially was followed longitudinally. After 5 to 6 years of BiCI use, 25 out of the 30 children were still consistent users of the second implant. Of these 25 children, 21 participated in the current study. EABR's were obtained with 4 Ag/AgCl electrodes at A1, A2, Cz and cheek (ground). Stimulation occurred via CS 3.2: biphasic pulses (PW: 50μs) at a rate of 39 pps evoked by electrode 11 at most comfortable level. Speech perception was tested with a phoneme recognition test (NVA children's test) at a fixed level of 65 dB SPL at 0° azimuth. Device use of both the CI1 and CI2 was categorised into a 5-point scale: "wearing all the time", "sometimes not wearing", "regularly not wearing", "only wearing in certain situations", "not wearing CI".

Results

Paired samples t tests showed that: no significant difference was found for wave III latencies between the first and second implant (wave III: t[17] = -0.1, p = .918). The average difference found for wave V latencies was not significant (wave V: t[18] = -1.0, p = .306). No significant difference in interwave interval III-V was found. Paired samples t tests showed that phoneme scores with the CI1 were significantly better than with the CI2 (t[23] = 3.0, p < .01). To assess the relation between phoneme scores, EABRs, device use and inter-implant delay, multiple regression analyses were carried out. When ΔEABR-wave V was controlled for, the effect of device use was no longer significant (p = .241). When device use was controlled for, a difference in wave V latency between CI1 and CI2 of 0.10 ms, resulted in a difference in phoneme score of 2.7% (95% CI: 0.2-5.2%).

Conclusions
This indicates that the less the second device is used, the larger the difference in EABR wave V latencies between both implants, which consequently leads to larger differences in speech recognition between both implants.

O47

ECAP latencies in sequential vs simultaneous cochlear implants

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No conflict(s) of interest.

Abstract
Some neurophysiologic events could explain the disappointing results in sequential implantation, and for this reason we studied the electrophysiologic behaviour of the Auditory Nerve, by measuring the ECAP latencies and comparing these values in simultaneously versus sequentially implanted patients.

Objectives
Evaluate the Auditory Nerve firing in simultaneous vs. sequentially implanted patients

Background
Tertiary referral hospital

Methods
165 patients bilaterally implanted were evaluated. The cohort was divided in two main group: simultaneous (53 children and 11 adults) and sequential (29 children and 72 adults).
The sequential were further divided considering the time between surgeries in “short delay” (less than 4 years) and “long delay" (more than 4 years).Every patient was evaluated considering the ECAP and the Speech Recognition (bilaterally and unilaterally) in two times: in the first month of bilateral implantation (only the ECAP) and after 4 years (ECAP and Speech test). All the patients were Nucleus device users and for this reason we used the Neural Response Telemetry choosing the electrodes 22 and 10 for each ear. To elicit the potential we used a stimulation rate of 80 Hz, 50 sweeps, gain 50 and delay of 120 microsec. The peak marker evaluated was N1. The data obtained were processed statistically using the Wilcoxon test (p<0,05) and Friedman test (p<0,05).

Results
The results in simultaneous patients showed not statistically significant differences between the ECAPs interaural latencies, while in sequential ones, the latencies of the second implant resulted anticipated if compared with the first implant.

Conclusions
Our results confirm that late stimulation generates an asymmetric neural activity. This asymmetry involves the hearing pathway at the very first level, as early as the first neuron. Considering the long- term sensory deprivation in sequential implanted, we expected a delayed neural response. But to our surprise we recorded just the opposite. These results definitely need further investigation. Our present orientation is to ascribe this phenomenon to a lack of tuning activity of the efferent system on the nerve.

O48

Asymmetric auditory brainstem development and function in children with bimodal (electric and acoustic) hearing

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Karen Gordon has a CIHR Operating Grant; Blake Papsin has Speakers' Bureau for Cochlear Corp.

Objectives
To restore binaural hearing in children with asymmetric hearing loss by providing bilateral input from one cochlear implant (CI) and one hearing aid (HA).

Background
As implantation criteria broaden, some children receive a unilateral CI despite considerable residual hearing in the contralateral ear. We asked whether acoustic stimulation in the non-implanted ear prevents abnormal changes to the bilateral auditory pathways we previously showed occur with unilateral CI use in young children.

Methods
Auditory brainstem responses were recorded in 19 children with 2.9±0.5 years of bimodal hearing. Responses were evoked by 11 Hz acoustic clicks presented to the non-implanted ear and biphasic electrical pulses presented to the implanted ear. Absolute response peak latencies and inter-wave latencies were compared for asymmetries in brainstem activity evoked by electrical versus acoustic stimulation. Nine children were asked which side of their head (left or right) they heard bilaterally presented clicks/pulses which varied in interaural level and/or timing.

Results
Brainstem latencies were significantly different in response to electric and acoustic stimulation ($F(1,18)=65.6, p=0.00$). There was a significant interaction between stimulation mode and wave ($F(1.3,23.2)=38.0, p=0.00$), indicating a neural conduction mismatch that increased from caudal to rostral auditory brainstem. Despite this large asymmetry, all children perceived changes in interaural level differences. Five children also perceived interaural timing differences.

Conclusions
While bimodal stimulation does not mitigate asymmetric brainstem development, some children detected changes in bilateral cues delivered with bimodal stimuli.

O49

Cochlear implantation as hearing rehabilitation method in single-sided deafness after acoustic neuroma surgery

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No conflicts.

Background
Cochlear implantation is one treatment option in single-sided deafness. So far, results were generated by implanting patients with a patent auditory nerve. Patients with sporadic vestibular schwannoma / acoustic neuroma (AN) may undergo tumor removal which can result not only in single-sided deafness but also structural damages or a loss of the auditory nerve.

Methods
Sixteen patients who received translabyrinthine AN surgery between 2010 and 2013 were analyzed in a retrospective study. In all patients an intracochlear placeholder was inserted during AN surgery in order to prevent cochlear obliteration. Extensive counseling on hearing rehabilitation options and testing of pseudo-stereophonic solutions including MRI follow-up was performed. Three patients received a CI. Audiological testing consisted of speech recognition in noise and localization measurements preoperatively as well as 12 months after first fitting of the CI. Subjective evaluation was administered using the SSQ questionnaire.

Results
Preservation of the cochlear nerve and insertion of an intracochlear placeholder could be achieved in all 16 patients during acoustic neuroma surgery using a translabyrhintine approach. One year after surgery, 3 patients chose no therapy at all or another form of SSD hearing rehabilitation. Another 9 patients opted for a preoperative CI evaluation including promontory testing (PT). In 4 patients PT has not been performed yet. Objective and subjective hearing rehabilitation results of the 3 CI patients are comparable to standard SSD patients.

Conclusions
Results after cochlear implant surgery in AN patients with preserved auditory nerve are comparable to patients with progressive or sudden onset of hearing loss confirming binaural hearing benefit. SSD hearing rehabilitation with a CI should be recommended to patients in whom the integrity of the cochlear nerve can be expected after acoustic neuroma surgery. Planning and counseling with regard to rehabilitation options, especially in translabyrinthine acoustic neuroma surgery, is essential, as an intracochlear placeholder is obligatory to allow electrode insertion later and prevent obliteration.

O50

Behavioral and Physiological Responses in Children with Unilateral Hearing Loss

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Abstract
Children with unilateral hearing loss (UHL) experience numerous difficulties in communication including

speech recognition in noisy situations. Although behavioral deficits have been identified, little is known about the underlying physiologic responses of the auditory system when listening with one ear. The current study investigated brainstem encoding of a speech syllable in children with UHL and age and gender matched peers with normal hearing (NH). Speech evoked auditory brainstem responses were obtained in quiet and pink noise at two signal-to-noise ratios. Speech recognition was assessed using monosyllabic words in quiet and noise and HINT sentences presented in the R-SPACE which simulates a complex listening environment with speech in the presence of restaurant noise. Results suggested group differences in physiologic responses for the onset, offset, fundamental frequency and second harmonic in either quiet or noise. Children with UHL performed more poorly than their peers in both quiet and noise on speech recognition measures. The findings further substantiate the detriments that children with UHL encounter in every day listening when they must rely on a single ear. Supported by NIDCD R01DC009010.

Objectives

The purpose of the present study is to investigate speech recognition in noise abilities and the speech-evoked ABR in children with UHL and NH.

Background

Children with unilateral hearing loss (UHL) experience numerous difficulties in communication including speech recognition in noisy situations. Although behavioral deficits have been identified, little is known about the underlying physiologic responses of the auditory system when listening with one ear.

Methods

Speech evoked auditory brainstem responses were obtained in quiet and pink noise at two signal-to-noise ratios. Speech recognition was assessed using monosyllabic words in quiet and noise and HINT sentences presented in the R-SPACE which simulates a complex listening environment with speech in the presence of restaurant noise.

Results

Results suggested group differences in physiologic responses for the onset, offset, fundamental frequency and second harmonic in either quiet or noise. Children with UHL performed more poorly than their peers in both quiet and noise on speech recognition measures.

Conclusions

The findings further substantiate the detriments that children with UHL encounter in every day listening when they must rely on a single ear.

O51

The effect of signal degradation and cochlear-implant experience on the uptake of durational cues during lexical access.

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Abstract

In normal hearing (NH), durational differences between syllables cue word boundaries. These cues facilitate lexical access because they can early disambiguate words that are embedded in other words (e.g., pain in *pain*ting) or across word boundaries (e.g. cancer in can sir). Duration cues are especially important for cochlear-implant (CI) users as they are reliably transmitted through the device. By means of eye tracking we study how durational cues modulate listeners' estimate of a lexical target as the signal unfolds over time, specifically to explore the effects of CI signal degradation and CI experience on the use of these cues.

NH listeners were tested with and without an acoustic CI simulation, in order to study the effect of degradation on listeners with no experience. This data were compared with data from CI users. Reliance on durational cues was studied by recording listeners' gaze fixations to four pictures displayed, showing a multisyllabic target (e.g., painting) and an onset-matching lexical competitor (e.g., pain), next to two unrelated distractors. Listeners were presented with sentences in which the target contained durational cues that were either coherent with the target or with the competitor.

NH listeners rely on durational cues and their gaze fixations are governed by the acoustic information. Degradation reduces this effect, it prolongs lexical competition and increases uncertainty about the lexical decision. CI users may re-gain the reliance on these cues through experience and their success in doing so can explain parts of the individual variability among CI users.

O52

Functional near-infrared spectroscopy brain imaging in patients with cochlear implants

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While the benefit of the cochlear implantation has been widely demonstrated for auditory perception, the study of functional neuroplasticity in the auditory-related circuitry in response to language and sound perception has been limited through the common neuroimaging techniques, such as functional magnetic resonance imaging (fMRI) or electroencephalography (EEG). The aim of this study was to evaluate the functional near infrared spectroscopy (fNIRS) as method for detecting brain activity in cochlear implant (CI) recipients. fNIRS measures changes in oxygenated and deoxygenated hemoglobin by monitoring the transmission of near-infrared light through brain tissue. Because fNIRS system doesn't interfere with any sort of electrical or magnetic device, it may be a useful alternative to the currently standard neuromaging techniques.In this study, we used fNIRS to measure the fronto-temporal cortical activity in 6 CI recipients (mean age: 47±19.1 years) and 4 normal-hearing adults (mean age: 43.8 ± 13.3 years) during two auditory tasks. In the first task, participants were required to judge pairs of rhymes and tones and indicate if they rhymed or matched. The second task required the passive listening to stories and long tones. The results demonstrated activation of the auditory cortex for all CI patients during all listening tasks. As predicted, active conditions (which required planning and executive function) elicited greater activation of the right frontal lobe in both CI and normal-hearing participants, while passive tasks did not. Additionally, the language conditions elicited activation of language-related areas in the left frontal lobe in both groups. A similar performance in accuracy and reaction times was found during the rhyme and tone judgment task across the two groups. These findings indicate that fNIRS is an effective tool to help understanding brain activity associated with hearing restoration in this patient population. Further investigation may clarify the functional reorganization of these brain areas over time in order to improve CI outcomes.

O53

Cortical Correlates of Voice Onset Time Processing Cochlear Implant Subjects

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Objectives
The primary purpose of this study was to obtain objective measures of voice onset time (VOT) processing ability in cochlear implant (CI) subjects in an effort to provide an index for speech perception outcome.

Background
Previous psychoacoustic work has shown that temporal processing is a crucial aspect of speech perception outcome in CI users. The ability to categorize stop consonants is heavily dependent temporal processing. The current study examined psychoacoustic categorical perception in a VOT /pa/-/ba/ continuum while at the same time used cortical evoked potentials to quantify neural processing of VOT. We hypothesized that the cortical responses to VOTs would be related to speech perception outcome in CI users.

Methods
Six VOT stimuli resulting a continuum were used. /pa/ and /ba/ stimuli were created by varying the VOT in 10 ms steps (0 to 50 ms). Subjects were instructed to press a button indicating whether they heard a /pa/ or /ba/. A 64-channel electrophysiological recording was used to record cortical responses to each of the VOT stimuli. All stimuli were presented acoustically in free field while the CI subject used their everyday CI setting.

Results
Subjects with “poor” speech perception exhibited categorical boundaries that were positively shifted compared to “good” users and normal hearing controls. All groups showed larger N1 responses to small VOT values, consistent with the previous literature in normal hearing subjects. Both CI groups showed smaller N1 responses compared to controls. Although subjects with poor speech perception tended to show smaller overall N1 responses compared to “good” users, the difference was non-significant. The only significant component that differentiated “good” and “poor” CI users was P2 latency such that "good" users had shorter P2s.

Conclusions
The preliminary data suggest that VOT differences can be reflected in cortical responses in CI users. The results suggested that P2 responses may serve to differentiate between good and poor users. This observation suggests that early stage processing, reflected by the N1, may serve to encode the stimulus, but subtle stimulus variations may require further cortical processing (i.e., P2) for successful identification. These findings are reminiscent of previous work showing a role of P2 in neural plasticity.

O54

Assessment of brain plasticity in adult cochlear implant users with Near Infra-Red Spectroscopy

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Objectives: The aim of the study is to validate the feasibility of using Near Infra-Red Spectroscopy (NIRS) to assess cortical plasticity in adult cochlear implant (CI) users.

Background: While many factors influence the auditory performance of CI users, the duration of sensory deprivation and the associated cerebral reorganizations are known to play a major role. Although a variety of noninvasive techniques can be used for detecting cortical activity in response to auditory stimuli, most have critical limitations when applied to CI users. NIRS appears as a viable alternative to measure hemodynamic changes in CI users in order to study the impact of cerebral reorganizations on auditory performances in deaf people using CI.

Methods: Our first experimental phase focused on designing a helmet adapted to the presence of a CI on and under the scalp. For the second phase, 10 adults with normal hearing and 2 groups of 10 CI users (with good and limited speech perception abilities respectively) will be recruited and assessed with two

tasks: a passive auditory task (repeated monosyllables) and a passive visual task (concentric circles with shape transformations). Hemodynamic activities will be recorded using 4 pairs of optodes per hemisphere, placed respectively on frontal, parietal, temporal and occipital lobes.

Results: Hemodynamic responses will be analyzed using a linear regression model including cortex location, participant's group and sensory modality of the task as independent variables.
Conclusions: The adapted helmet and the preliminary hemodynamic responses obtained from each group with this instrumentation will be presented.

O55

Can we preserve bilateral symmetry in the developing auditory cortex with electric and acoustic (bimodal) hearing?

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Karen Gordon has a CIHR Operating Grant; Blake Papsin has Speakers' Bureau for Cochlear Corp.

Objectives
To preserve bilateral auditory cortical development in children who use both a cochlear implant (CI) and hearing aid (HA).

Background
Prolonged unilateral CI use and auditory deprivation of the non-implanted ear leaves the auditory cortex vulnerable to reorganization, leading to abnormal cortical activity patterns. However, some children with unilateral CIs have residual hearing in their contralateral ear. We ask whether the auditory cortex is protected from reorganization in these children through bimodal bilateral input (electric input in one ear and acoustic in the other).

Methods
Electroencephalographic measures of cortical activity were recorded across 64-cephalic electrodes in 11 children who received bimodal input for 2.1 ± 0.4 years. Responses were evoked using 250 Hz acoustic clicks and biphasic electric pulses in 36ms trains presented at 1 Hz. A beamforming method developed in our lab has been shown to successfully suppress CI artifact, separate neural activity from the noise floor, and locate underlying sources (dipoles) of the cortical waveforms.

Results
Preliminary results show variable waveform types, including a large positive peak, bifid peaks, and mature-like waveforms. Morphology of waveforms differed when evoked by electric and acoustic stimulation in children. Strength of the underlying dipole activity will be measured, localized across the brain, and analyzed for differences between left and right cortical hemispheres and aural preferences (i.e., acoustic versus electrical stimulation).

Conclusions
Results will highlight cortical development promoted by bimodal stimulation and will begin to answer whether bimodal stimulation can be used to protect the auditory cortex from unilaterally driven reorganization.

O56

Speech processor fitting using Nucleus Fitting Software (NFS)

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Objectives: The Nucleus Fitting Software (NFS) is a new, simple programming system by Cochlear Ltd. that is suitable to create NRT based-MAPs for cochlear implant recipients. The aim of this study was to compare the MAPs and patients' performance using the new NFS and the traditional Custom Sound systems, respectively.

Material and methods: A prospective comparison study was conducted with 23 patients fitted with the standard Custom Sound and the new NFS softwares. We performed three types of fitting sessions. We made a MAP based on subjective hearing scale, a MAP based on NRT and a MAP using NFS. Three months after the fitting procedure, the auditory performance and the patients' preference were analysed.

Results: Our results showed that the fitting period was significantly shorter using the NFS system than using Custom Sound software. In terms of measuring hearing threshold and speech understanding, there was no significant differences between the selected groups. Patients' preferences showed big variety but some of the patients preferred the MAP created with NFS software.

Conclusions: The NFS system is an easily applied fitting software that requires a short time for MAP creation. Technicians and speech therapists with less experience can make usable MAPs for cochlear implant users.

O57

Evoked Compound Action Potentials (ECAP) measures in pediatric MED-EL cochlear implantees: relationship with electrode placement, age and C-levels.

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Objectives
1) measure the success rate of the Evoked Compound Action Potentials (ECAP) using MAESTRO System Software 4.0 (MED-EL) via the Auditory Response Telemetry (ART) module in children; 2) compare ECAP responses between different cochlear stimulation sites (apical, middle and basal, electrodes 2, 6 and 10, respectively) in children; 3) determine the effects of age at implantation and the duration of cochlear implant (CI) use; and 4) to determine whether ECAP thresholds can predict C-levels in children.

Background
66 cochlear implanted children from the Annaba University Hospital in east Algeria.

Methods
ECAP responses were recorded in 66 children (1-6 years old). The maximum stimulation levels (charge unit, qu), the ECAP response amplitudes at the maximum stimulation level (microvolt), the ECAP thresholds and the C-level (qu) at each stimulation site were determined. Children were divided into two groups; group 1 - implanted before 3 years; and group 2 - implanted after 3 years of age. Cochlear implant surgery, follow-up and testing were all performed at the Annaba CI Centre, Algeria.

Results
ECAP recording in children with a MED-EL CI was successful in >87% cases. ECAP amplitudes were larger at the apex than at the base of the cochlea. There was a significant positive correlation between ECAP amplitudes and the duration of CI use at the middle and at the base of the cochlea, but not at the apex. C-levels were statistically different between electrodes, with the lowest C-level at the apex, then at the base and the highest C-level in the middle. ECAP thresholds were correlated significantly with C-levels at the apex and in the middle of the cochlea in children implanted before 3 years of age. There were no significant correlations between C-levels and the stimulation site in children implanted after 3 years of age.

Conclusions
The differences observed across cochlear stimulation sites suggest various degrees of neuronal survival rates and/or physiological reaction to long-term CI electrical stimulation along the cochlea. Results from children implanted before 3 years of age indicate young age at implantation is beneficial. The present study confirms that ECAP measurements provide useful information for CI fitting in children.

O58

Towards A Clinically Viable Way To Record Cortical Auditory Evoked Potentials (CAEPs) In Cochlear Implant (CI) Clients

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Objectives
The aim of this study is to evaluate whether a single-channel CAEP recording system can be modified sufficiently to allow clinical use in the fitting of cochlear implants.

Background
CAEPs have been used as an objective electrophysiological measure to assist hearing aid fitting. However, clincial application of CAEPs to cochlear implants (CIs) is impeded by the presence of an electrical artefact.

Methods
A hardware modification of the single-channel clinical HEARLab system reduced artefacts by more than 20 dB. An additional software modification to the automatic CAEP detection reduced its susceptibility to any remaining CI artefacts significantly without loss of CAEP detection sensitivity (based on a pilot study with 25 adult Cochlear users).

Data collection on 34 additional CI adults (now with 3 different CI manufacturers: 9 ABC, 12 MED-EL and 13 Cochlear), incorporating a specific stimulus condition which only can generate CI artefacts – and

hence no CAEPs - has been completed. This condition removed any possible confusion between CAEPs and artefacts, a common problem when evaluating CAEPs in CI subjects.

Results
False-positive CAEP detections using the automatic CAEP detector are still occurring in the specific stimulus condition that produces CI artefacts only. In response, a CI artefact detector to warn the clinician has been developed. Preliminary results show that the CI artefact detector has a specificity and sensitivity of at least 90 and 85% respectively, with still room for improvement. Artefact and CAEP prevalence are manufacturer- and stimulus-dependent. It will be discussed whether single-channel recording of CAEPs in CI subjects is clinically viable, and what the optimal parameter settings then would be for both the CI artefact and CAEP detectors.

Conclusions
The current hardware of the single-channel CAEP recording system HEARLab with software modifications allows an improved CAEP detection sensitivity with reduced susceptibility to CI artefacts. However, in some cases these artefacts are still apparent and difficult to remove. If so, a detector could warn the clinician of their presence to avoid false interpretations.

O59

Relating objective measures of auditory function to behavioural speech outcomes among high level adult performers with the MED-EL Flex Electrode

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Objectives
The aim of this study is to determine whether there are objective measures predictive of above average speech performance in CI users. Our hypothesis is that adult CI recipients deemed to be “above average” performers will differ in their neurophysiologic responses recorded at one or more levels of the auditory pathway (i.e., electrically evoked compound action potentials (eCAP) and cortical auditory evoked potentials (CAEPs)).

Background
Numerous studies have looked for physiological measures to predict auditory nerve survival as a means of exploring CI outcome. Animal studies have indicated a correlation between eCAP measures and auditory nerve survival while recent human studies have shown a relationship between speech performance and the slope of the ECAP growth function. Other research has correlated speech performance to certain features of cortical auditory evoked potentials (CAEPs). The current study confirms such findings and will explore emerging trends.

Methods
18 adult CI recipients, mean age of 63 years, (8 “above average” and 10 “average”) were included. “Above average” performers were defined as CI recipients who scored greater than 80% on AZBIO sentences at 3 months post activation and improved more than 20% on CNC words over the same period. Participants were evaluated on measures of ECAP at four time points: at CI activation, at 1 month, and at 3 months, and at 6 months. CAEPs were measured at 3-months post CI activation. Speech testing consisting of AZBIO in quiet and noise and CNC word testing was carried out at all time points. Differences in evoked potential responses and behavioural measures of speech (AZ BIO and

CNC words) between the two groups were examined for statistical significance.

Results
Results of CAEP recordings indicate better N1 and P2 latencies for the “above average” performers and lower apical electrode impedances at CI activation ($p< 0.05$). “Above average” performers were younger (mean of 59 years vs. 67 years), had better speech performance at CI activation, and had better qualitative ratings of implant performance as measured on SSQ and HISQUI, all $p< 0.05$. Subsequent analyses will present ECAP findings in relation to speech performance.

Conclusions
Evidence indicates that "above average" implant performers have notable differences in objective measures of auditory neural survival and auditory processing compared to "average" implant performers. Similar studies will help us explore and determine characteristics of objective measures that can help guide CI outcomes.

8TH INTERNATIONAL SYMPOSIUM
on objective measures in auditory implants

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Poster Abstracts

Poster Abstracts

P01

Near-infrared spectroscopy detects differences in auditory cortical activation across cochlear implant configurations

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Objectives
Determine if near-infrared spectroscopy (NIRS) can detect auditory cortical activity differences between cochlear implant (CI) hearing configurations.

Background
There are currently no research-based criteria for determining candidacy for a second CI (bilateral CI vs. bimodal hearing). An objective measure of bimodal and bilateral benefit, such as neuroimaging, could help to determine candidacy in young children difficult to test behaviorally. NIRS can be used in young children with CIs but its utility is unknown with only one published study.

Methods
Auditory cortical activity was measured using NIRS in adults with bilateral CIs or bimodal hearing and NIRS and functional magnetic resonance imaging (fMRI) in normal-hearing adults listening to CI speech simulations. Conditions included unilateral CI in each ear, bilateral CIs, and bimodal hearing simulations for normal-hearing adults and each ear separately as well as bilateral CIs or bimodal hearing in adults with CIs. Participants rated the intelligibility of each listening condition during testing.
Results
NIRS revealed differences in auditory cortical activity between simulation conditions differing in site of sound stimulation (one vs. both ears) in normal-hearing adults. NIRS and fMRI results were qualitatively consistent. Preliminary data in adults with CIs indicate NIRS detected differences in auditory cortical activity between stimulation of each ear and unilateral vs. bilateral conditions.

Conclusions
NIRS can detect differences between CI simulation conditions consistent with the literature and fMRI results. Thus NIRS shows potential as an objective measure of the benefit of a hearing aid in the non-implanted ear or a second CI.

P02

Cortical Auditory Event-Related Potentials in Children with Auditory Brainstem Implants

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No conflicts to be disclosed.

Objectives
This study aimed to determine the feasibility of measuring the electrically-evoked cortical auditory-event related potential (eERP), including the onset eERP and the auditory change complex (eACC), in children with auditory brainstem implants (ABIs).

Background
The programming process with pediatric ABI patients is complicated and extremely challenging. To date, there is no reliable indicator for identifying which electrodes produce non-auditory sensation or selecting optimal programming parameters for individual patients with ABIs. In addition, little is known about temporal resolution abilities in these patients. This project aimed to address these needs.

Methods
Four pediatric Cochlear Nucleus ABI users ranging in age between 3.1 to 10.4 years participated in this study. The speech processor was bypassed and the stimulus was directly delivered to individual electrodes. For onset eERP measures, the stimulus was a 100-ms biphasic pulse train presented at a series of stimulation levels. For the eACC measure, the stimulus was an 800-ms biphasic pulse train presented at the maximum comfortable level in gapped and non-gapped stimulation conditions. Gap durations tested in this study included 10, 20, 50, 100 and 200 ms.

Results
The onset eERP and the eACC were recorded from multiple electrodes in three ABI patients who demonstrate sound awareness with their devices. eERPs were not recorded from any electrodes in one ABI patient who did not show behavioral responses to sound. Morphologies of neural responses evoked by non-auditory stimulation were different from those of eERPs evoked by auditory stimulation.

Conclusions: eERPs can be measured from children with ABIs.

P03

Auditory Perception and Neural Representation of Voice Onset Time in Children with Auditory Neuropathy Spectrum Disorder

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No conflicts need to be reported

Objectives
This study aimed to evaluate the association between auditory perception and neural representation of voice onset time (VOT) in quiet and in noise in children with auditory neuropathy spectrum disorder (ANSD).

Background
VOT is a temporal cue for differentiating voiced and voiceless English stop consonants. To date, no study has evaluated neural representation of VOT in the central auditory system and its association with categorical perception in children with ANSD. Moreover, no study has investigated effects of competing noise on neural encoding and auditory perception of VOT in these patients. This project addresses these needs.

Methods
The stimulus set was an /aba-apa/ continuum presented at 35 dB SL in quiet and in noise at a signal-to-noise ratio of 10 dB. VOTs tested included 0 (voiced endpoint), 9, 19, 29, 39, 50, 60, and 70 ms (voiceless endpoint). Consonant identification functions and acoustically evoked cortical auditory event-related potentials (ERPs) were measured from seven children with ANSD ranging in age between 5 to 13.3 years. All subjects were tested monaurally without their hearing aids.

Results

The categorical boundary determined by consonant identification as a function of VOT and ERP measures showed a close association. Adding a background noise shifted categorical boundaries towards the voiceless endpoint using both measures. Moreover, neural encoding of VOT was less accurate and sensitive in noise than in quiet.

Conclusions
Categorical perception and neural encoding of VOT are closely associated in children with ANSD. Adding a competing noise adversely affects neural representation of VOT in these patients.

P04

Electrically Evoked Compound Action Potentials in response to Amplitude Modulated Electric Pulse Trains

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Work supported by NIH grants P50 DC 000242 and R01 DC 012082

Temporal modulation transfer functions (TMTFs) measured using electrical stimuli in cochlear implant (CI) users have suggested a low-pass cutoff of less than 300 Hz (Shannon, 1992; Chatterjee & Robert, 2001). Less is known about the response of the auditory nerve to amplitude modulated electrical stimuli, though such responses have been recorded in animals and in Ineraid implant users (Abbas et al., 2003; Wilson et al., 1995). In the present experiment, the electrically evoked compound action potential (ECAP) was recorded in Nucleus CI users in response to sinusoidal amplitude modulated (AM) biphasic pulse trains presented to a basal, medial, and apical electrode. The carrier rate was 2000 Hz, and AM rates were 125, 250, and 500 Hz. The ECAP responses were measured over the last two cycles of the modulated pulse train and amplitudes clearly varied at the modulation frequency. Preliminary data suggest that maximal ECAP amplitude increases for all subjects as modulation rate increases from 125 to 500 Hz. This trend is evident regardless of the electrode location and is hypothesized to be the result of adaptation effects across the duration of modulation. There are also within subject variations of ECAP responses that arise from the use of different electrode locations, consistent with previous psychophysical studies of AM discrimination in CI users (Pfingst et al, 2008).

P05

Forward masking in the human auditory nerve: comparing eCAP recovery functions for single-pulse and pulse-train maskers.

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No conflicts.

Objectives
To compare electrically-evoked compound action potential (eCAP) recovery functions for maskers of different durations, levels and pulse rates in cochlear implant (CI) users.

Background
Forward masking in CIs tends to be seen as a two-stage process with short and long recovery time constants occurring at the cochlear and at more central levels, respectively. However, recent animal data suggest that the recovery time constant at the auditory nerve level may be longer than previously thought.

Methods
eCAPs were measured from a group of Cochlear Freedom users. A single pulse probe was presented with or without a preceding masker. Maskers consisted of (i) a single pulse masker (SPM), (ii) a 300-ms low-rate pulse train masker (LTM, 250 pps), and (iii) a 300-ms high-rate pulse train masker (HTM, 5000 pps). eCAP recovery functions were obtained by measuring the probe response for masker-probe delays ranging from 1 to 512 ms.

Results
When masking occurred, it diminished at larger masker-probe delays. The recovery time constant of SPM was fast and no masking was observed for delays greater than about 8 ms. With LTM and HTM, recovery time constants were much longer and significant masking was sometimes observed for long delays (128 ms). When compared at the same current level, masking increased for SPM, LTM and HTM, respectively.

Conclusions
The time constant of peripheral forward masking strongly depends on the duration of the masker and seems consistent with time constants measured psychophysically for pulse-train maskers.

P06

Methods for achieving balanced current levels in children with bilateral cochlear implants

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Objective
A research interface is presently required to provide coordinated input to bilateral cochlear implants and likely unavailable in most clinical settings. We therefore sought a method to provide balanced stimulation levels for children using bilateral cochlear implants (CIs).

Method
Twenty-four children (7 to 17 years of age) received their first CI at 3.3±1.6 years of age and their second CI in the opposite ear 9.2±2.7 years later. Due to the long inter-implant delay, most of the children received different generations of Nucleus devices on each side. Bilaterally balanced levels, stimulated with a research interface and measured using a lateralization procedure, were compared to two methods: 1) matching EABR amplitude from each CI and 2) matching loudness growth across the dynamic range for each CI. Testing occurred after children had a short period of bilateral implant use (1 month) and was repeated ~8 months later.

Results
Matching eV amplitudes provided stimulation levels close to those perceived as balanced in most children. By contrast, input was often perceived as louder in the second than the first CI which lead to a lateralization of bilateral input toward the first CI. This was true at both test times.

Conclusion
Programming bilateral cochlear implants is best completed by presenting bilateral input and using a lateralization task. It is best to predict these levels, at least in children, by matching amplitudes of brainstem responses evoked by each device rather than loudness judgements of each implant alone.

P07

Relation of loudness and electrically evoked compound action characteristics

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Objective
To investigates the relation between loudness ratings and results from the electrically evoked compound action potentials (ECAPs).

Background
In cochlear implant (CI) fitting, typically objective measures are only used to predict the upper and lower stimulation levels. However, for fitting of parameters influencing the mapping within the electrical dynamic range feedback of users is essential. Therefore objective correlates for the loudness growth are highly desired.

Method
ECAP amplitude growth functions were recorded in 18 Advanced Bionics CI users using RSPOM (Research Platform for Objective Measures). ECAP threshold was defined as the intersection of a linear regression line with the abscissa. Only the linear part of the growth function was respected and noise floor and saturation were omitted. An adaptive loudness scaling procedure was performed on the same electrodes with bursts of similar pulse width using direct electrical stimulation. The loudness growth function and iso-loudness profiles were derived from the loudness ratings.

Results
In more than 95% of measurements a reasonable linear regressions could be derived. Reasons for failure were too small signal to noise ratio, too high stimulus artifact or too small number of recordings with a monotone amplitude growth. The profile of ECAP thresholds follows the profile of iso-loudness curves. Data collected so far do not show a correlation between ECAP slope and loudness growth slope.

Conclusion
Further investigation is required to derive conclusive correlates for loudness from ECAP characteristics.

P08

Suitability of the binaural interaction component for interaural electrode pairing of bilateral cochlear implants

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Objectives
It has been shown in animal experiments that the magnitude of the binaural interaction component (BIC) derived from the wave-eV regime (i.e. the brainstem or the inferior colliculus), decreases for increasing interaural place of stimulation mismatch. However, a replication of these results in human subjects has not been performed in a fully convincing manner. Challenges are the small mean-to-sigma ratio of the BIC as well as EEG artifacts (electric pulse, facial nerve). Here a new attempt is made by employing multi-channel EEG and novel analysis methods.

Background
Pairing matched interaural CI electrodes and stimulating them with the same frequency band is expected to facilitate binaural functions such as binaural fusion, localization, or spatial release from masking.

Methods
Bilaterally implanted subjects are directly stimulated at 60% dynamic range with 19.9 pulses per second. The BIC is derived for several interaural electrode pairs by subtracting the response from binaural stimulation from their summed monaural responses. A 60+ channel brainstem EEG recording is performed. For data analysis the first millisecond after stimulation is removed and an independent component analysis is performed. For comparison pitch ranking and left-right discrimination were measured with the same stimuli.

Results
A strong benefit of the signal quality could be demonstrated with the multi-channel recording compared to conventional 1-2 channel eABR. For some, but not all subjects the maximum BIC could be determined for place matched electrodes.

Conclusions
BIC based electrode pairing is a promising objective interaural electrode pairing method, but not yet suitable for an audiology or clinic routine.

P09

Frequency Following Response to Interaural Phase Changes – A Potential Objective Measurement for Binaural Fitting

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Objectives
The aim of this study was to develop an objective measure of binaural processing for cochlear implant (CI) users. We first tested the method with normal hearing (NH) listeners and we are now adapting it for CI listeners.

Background
A place mismatch between the channels in each ear may reduce the binaural performance of bilateral CI users. This may be resolved partially by developing a reliable objective measure of binaural processing to aid matching across-ear electrodes.

Methods
We measured the frequency following response to abrupt interaural phase changes (FFR-IPCs) imposed on a dichotic amplitude modulated 500-Hz tone from NH listeners. The phase of the carrier signal presented to each ear was manipulated to produce discrete periodic interaural phase changes (IPCs) at minima in the modulation cycle. Carrier phases were symmetrically opposed in each ear in order to create interaural phase differences (IPDs) that ranged between 11 and 135◦. IPCs were presented at 3.4, 6.8, and 13.6 switches/s. The carrier was amplitude modulated using several rates (27 to 109 Hz).

Results
FFR-IPC could reliable obtained from all participants and were stronger than the commonly recorded binaural interaction component (BIC). The SNR was largest at IPCs of 6.8 switches/s and for IPDs between 45 and 90◦. Responses increased with amplitude -modulation rate.

Conclusions

FFR-IPC may be more suitable than BIC as an objective measure to match across-ear electrodes. Preliminary data from CI users will be also presented.
The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under ABCIT grant agreement number 304912.

P10

Signal coding and perception of Iterated Noise with Cochlear Implant users

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This study is co-funded by Cochlear Europe Ltd.

Pitch is one of the primary auditory percepts and is one of the most important perceptual features in music. Pitch-related auditory activity can be identified by using iterated ripple noise (IRN) as pitch-evoking stimuli. IRN is created by generating a sample of Gaussian noise, imposing a delay to the noise, and adding (or subtracting) the delayed version back to (or from) the original. The pitch sensation of IRN is determined by the reciprocal of the imposed delay. Varying the number of iterations an individual threshold (just noticeable difference, JND) can be determined for the pitch percept. With Nucleus ACE sound coding strategy in CI patients, also fixed frame-onset interval is used. This might be one reason that CI users often report a perception of a single pitch ringing. If IRN is maintained by CI users in terms of inducing pitch percepts, the strengths of the percept can be measured objectively by auditory evoked potentials
We measure the pitch onset electrophysiological response (POR) in a paradigm, in which a continuous sound is constructed from a segment of noise and a segment of IRN with the same energy and a very similar spectral profile. The JND for IRN is measured with normal hearing subjects and CI users. In CI users with single-sided deafness the perceived frequency of IRN is determined subjectively. The first result with normal hearing subjects and CI users are presented.

P11

Auditory evoked responses to pitch matched electroacoustic stimuli in unilateral cochlear implant users with residual hearing in the unimplanted ear

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Background
Some unilateral cochlear implant (CI) patients who have residual hearing in their unimplanted ears are able to compare the pitch percepts elicited by electrical stimulation with those elicited by acoustic hearing.

Objectives
The goal of this study is to use the changes in the pitch percepts elicited by a given electrode over time as a metric to examine the perceptual process in adapting to their devices, after implantation.

Methods
Pitch percepts were evaluated psychoacoustically and physiologically in 11 CI users and 10 normal

hearing (NH) listeners. CI users were asked to adjust the frequency of an acoustic tone presented to the non-implanted ear to match the pitch percept elicited by electrical stimulation delivered by a single intracochlear electrode to the implanted ear; six repetitions for several electrodes in the implanted array. Auditory Evoked Potentials (AEP) were recorded in CI users in response to interleaved presentations of electrical stimulation of a single intracochlear channel and acoustic tones delivered contralaterally. One of these tones was pitch-matched to the electrode and the other tones were not. For normal hearing listeners, a 500 Hz acoustic tone replaced electrical stimulation.

Results
For CI patients, N1 latency was minimized when the acoustic and the electrical stimulus were pitch-matched. In the case of NH listeners, N1 latency was minimized when both ears were stimulated with the same frequency.

Conclusions
N1 latency could be a potential marker of acoustic-electrical pitch matching in CI users and help in interpreting the behavioral results.

P12

Recordings of acoustic evoked potentials directly from the different places of cochlea via intraochlear electrodes in cochlear implantees.

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Abstract
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 1.5kHz 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. Currently, there are available only studies recording the acoustic potentials via far field recordings (i.e. using a clinical ABR technique) or intraoperatively via an electrode placed in the vicinity of the round window.

However, none of these approaches allows us to get better understanding of pattern of excitation within the cochlea. Specifically, using such measurement set-ups it is not possible to obtain frequency specific information.
Our pioneering work showed that recordings of acoustic evoked potentials directly from the different places of cochlea are possible.

The paper will present a new method of recordings via intraochlear electrodes and its possible use in cochlear implantees.

P13

An Investigation of the Auditory Brainstem Response Wave Amplitude Characteristics as a Diagnostic Tool in children with Speech Delay with Unknown Cause

Susan Abdi (Azad University)

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

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) this amplitude was significantly reduced after a six months of treatment (p=0.003) but it still was significantly higher than the control group (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.

Conclusions
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.

P14

Variability Across Single-Trial ECAPs and the Relation to Speech Perception

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NIH R01 DC009595 05; NIH R01 DC013281 01A1; NIH T32 DC000013 34

Objectives
To characterize electrically evoked compound action potential (ECAP) cross-trial variability and its relation to speech perception.

Background
The ECAP is an aggregate response of electrically stimulated auditory-nerve fibers. Single-fiber response characteristics (e.g. firing probability, threshold, and latency) vary across the population of neurons and across cochlear-implant users. The ECAP is typically measured by averaging 50–100 trials. Single-trial variability, which may reflect single-fiber variability, likely contributes to differences in amplitudes and latencies across averaged ECAP waveforms. Greater variability across trials may indicate a compromised system. It was hypothesized that greater variability would be observed for lower stimulus levels and for participants with poorer performance.

Methods

One hundred single-trial ECAP waveforms were recorded using a standard forward-masking subtraction paradigm. Recordings were obtained on three electrodes, each stimulated at 10, 30, 50, 70, and 90% of the range between ECAP threshold and upper comfort. For each single-trial waveform, N1-P2 amplitudes were calculated. Variability was quantified as the standard deviation across single-trial amplitudes relative to the grand-mean amplitude.

Results
Preliminary results suggest greater single-trial variability for lower stimulation levels. Single-trial variability differed across participants and electrodes; the most deviant trials appeared to have a non-neural (possibly device-related) source. The presence of aberrant traces was not obvious in the averaged response.

Conclusions
The relation between single-trial variability and speech perception will be discussed for a larger number of participants. The source of non-neural noise in the single-trial recordings, which may have implications for the interpretation of standard ECAP recordings, is under investigation.

P15

Poster Withdrawn

P16

Predictive value of evoked compound action potential (ECAP) in cochlear implant outcomes

Sarah Sydlowski (Cleveland Clinic)

No conflicts.

Objectives
The primary aims of the research were to investigate relationships between advanced intra-operative objective measures and:

1. known indicators of successful cochlear implant (CI) outcomes including duration of auditory deprivation and age at implantation;
2. contemporary electrode arrays; and
3. CI outcomes (measured using speech recognition scores)

Background
The evoked compound action potential (ECAP) has been shown to be reliably recordable for the majority of patients and is a valuable tool for verification of CI function, evaluation of responsiveness of the auditory nerve to electrical stimulation, estimation of required current level for an introductory MAP, establishment of baseline responses for monitoring function over time, and estimation of neural survival and benefit; however, a predictive relationship between ECAP measures and outcomes using contemporary technology has not been reliably quantified.

Methods
A retrospective chart review of >100 patients undergoing cochlear implantation with current Cochlear Americas™ devices including intraoperative testing using advanced measures was completed. Factors considered included age at CI, duration and degree of hearing loss, electrode array, spread of excitation (SOE) width, amplitude growth function (AGF) threshold and slope, ECAP amplitude, recovery functions, and best pre- and post-operative speech recognition scores.

Results
Patterns of neural responsiveness observed intra-operatively using advanced measurement techniques offer interesting insight into the value of ECAP results (beyond thresholds) and their clinical utility for CI outcomes estimation.

Conclusions
Advanced ECAP measures contribute supplementary information from which to draw inferences regarding potential outcomes following cochlear implantation and could have clinical applicability beyond information obtained using standard measures.

P17

GJB2 related deafness and electrically evoked auditory brainstem response recorded during cochlear implantation

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The authors have no conflict of interest to disclose

Objectives
In this study we aimed to investigate the relation between GJB2 related deafness and electrically Evoked Auditory Brainstem Responses (eABR) recorded at the time of cochlear implantation.

Background
DIGISONIC SP® cochlear implants (CI) use variable time-pulse for sound coding between comfort and threshold levels. Accordingly, we previously described the impact of modulating phase duration on auditory brainstem responses at different site of the cochlea.

Methods
Auditory brainstem responses evoked by a biphasic pulse train, at increasing phase duration (pulse width, T-pulse), were recorded in 188 subjects at the time of cochlear implantation. All patients were fitted with a NEURELEC CI device, initially DIGISONIC® then DIGISONIC SP® (2004-2006).

Results
The mean age at implantation was 22,9 years, ranging from six months to 80 years. Clinical evaluation in that population allowed identification of a causative or precipitating pathology in 55% (104/188). Eighty-eight patients (46,8%) became deaf before the first year of life (Early onset deafness). In this group, the implantation age was 2,9 +/- 1,4 years. Forty-two subjects (22,3%) were genetically predisposed; nineteen (10,1%) GJB2-related deafness were identified (12 were homozygote carriers of the 35delG mutation). Stimulation by the CI resulted in reliable wave III and V eABR waveforms (wave V 4.28+/-0.42 ms and 2.23 +/- 0.38 ms for wave III (Mean +/- SD)) with latencies following an apical to basal gradient (0.32 ms increase in mean eV latency and 0.12 ms for eIII latency).

Conclusions
We report the result of eABR registered during cochlear implantation of Neurelec CIs using a single set of stimulating parameters. We describe our results with emphasis on GJB2 related deafness.

P18

A coupled clinical-experimental approach for estimating real CI stimulation artifacts

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Abstract
Auditory evoked potentials (AEPs) are proven to be a useful objective measure of both auditory detection and discrimination in normal-hearing subjects and can thus be applied to CI users to evaluate the CI efficiency. However, evaluating these measures in CI users is hindered by the contamination of the AEPs by the electrical CI artifacts. The estimation of these artifacts can help develop efficient processing methods which can be applied for clinical use. Here we propose to record, in response to acoustic stimulation, the electrical artifacts generated from a CI (with both internal and external parts) implanted in a phantom (melon) wearing an EEG cap. Simultaneously and in synchrony, AEPs to the same acoustic stimulation are recorded with a 32-channel EEG cap placed on the scalp of a normal-hearing subject. The interest of using this methodology is twofold. On the one hand, it allows the recording of preliminary EEG datasets (AEPs artificially mixed with CI artifacts) useful for developing and evaluating new signal processing methods of AEPs-CI artifact extraction (e.g., ICA, subtraction methods, spatial filters, etc.) prior to their clinical application in CI users. On the other hand, the AEPs obtained with normal-hearing participants in response to auditory stimulation constitute a set of control data which can be compared to that of CI users. In addition, to approximate the AEPs that can be expected from CI users, acoustic stimulation which simulates the CI speech processor coding (such as noise-vocoded speech) can be used with normal-hearing subjects.

P19

Visualization of Human Inner Ear Anatomy with High Resolution Magnetic Resonance Imaging at 7 Tesla: first clinical evaluation.

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Objectives
To investigate the applicability of clinical inner ear imaging at 7 Tesla MRI and to compare the visibility of inner ear structures and nerves within the internal auditory canal at 3 Tesla images.

Background
In many centers MRI of the inner ear and auditory pathway - performed on 1,5 or 3 Tesla systems - is part of the preoperative work-up of CI-candidates. A higher magnetic field strength results in a higher signal-to-noise ratio that can be used for more detailed imaging than previously possible and therefor improve

surgical planning, morphological calculations and prediction of functional success.

Methods
13 patients with SNHL eligible for cochlear implantation underwent an examination on a 3 and 7 Tesla scanner. Two experienced head and neck radiologists evaluated the 52 depicted inner ears. A total of 24 anatomical structures of the inner ear were assessed using a 4-point-grading scale for degree of visibility for diagnostic evaluation.

Results
The visibility of 14 out of the 24 anatomical structures was rated higher on the 7 Tesla images. Three anatomical structures were better depicted on the 3 Tesla images. There was no significant difference in the overall quality rating and visibility of 8 anatomical structures. A higher incidence of artifacts was observed in the 7 Tesla images.

Conclusions
A significant progress was made towards the use of 7 Tesla MRI for clinical inner ear scanning. The gain in SNR demonstrated a more detailed visualization of the majority of anatomical structures despite the remaining difficulties accompanying high magnetic field.

P20

Electrocochleography (ECoG) and its interpretation in cochlear implant subjects

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Objectives
To characterize ECoG signal in terms of contributions from hair cells and neural sources when recorded at the round window or within the cochlea of CI patients. The measurements were made in an animal model with a hearing condition typical of cochlear implant subjects before and after the neural potentials were chemically removed.

Background
ECoG can be used to characterize cochlear physiology prior to implantation as a guide to expected outcomes and to monitor cochlear trauma during surgery. The interpretation of the ECoG would be improved by an ability to identify the particular sources that contribute to the complex signal.

Methods
Gerbils were exposed to a high pass noise to achieve a sloping pattern of hearing loss. Four weeks after exposure, ECoG signals to tones of primarily low frequencies (<2000 Hz) and varying intensities were recorded at the round window before and after application of kainic acid, a neurotoxin.

Results
Application of KA showed the cochlear microphonic and summating potential to be preserved, and the action potential, auditory nerve neurophonic, and a neural contribution to the envelope to be removed. The harmonic distortion was greatly reduced. Major factors that differentiate the noise exposed from normal hearing animals are loss of source generators and spread of excitation.

Conclusions
The results in animals can improve the ability of ECoG recordings to contribute information about individual CI recipients.

P21

Cochlear Implantation in a young adolescent with a progressive hearing loss and Auditory Neuropathy Spectrum Disorder (ANSD)

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Aims
To present the pre implantation assessmentin a young adolescent with a progressive SNHL and ANSD and to compare the assessment results with post implantation outcomes.As well to highlight the dilemma surrounding the choice of CI as the preferred option for auditory rehabilitation in this case.

Clinical findings
Pre-implantation: MS, son of deaf parents, developed full spoken language abilities and was followed up for a period of seven years from his referral at the age of five. During the review period his hearing, which began as a mild-moderate bilateral hearing loss, fluctuated and progressively deteriorated to a severe-profound loss in the ear that was eventually implanted. MS's abilities gradually deteriorated from a limited ability to understand speech in open set listening conditions to a total reliance on speech reading together with a complete loss of any functional benefit from hearing aids (0% speech understanding). Objective measurements revealed abnormal ABR, presence of OAE's with absent Stapedius reflex – leading to a diagnosis of ANSD.

6 months following implantation: No responses of the auditory nerve were recorded using objective measurements (Neural Response Telemetry- NRT). Development of speech understanding in open set: 80% everyday sentences, 45% mono syllable words. Recently he has also managed to hold a simple conversation on the telephone for the first time.

Discussion
MS developed good speech perceptionabilities within 6 months following implantation, similarly to other successful implantees in his peer group. It is clear that in this case the concerns regarding implant surgery were not justified and he possibly could and should have been implanted at an earlier date. This result highlights the ongoing need for development of clinically applicable assessment procedures which will be possible to shorten the length of the assessment period and the time taken to reach a decision regarding implantation in this group.

P22

Electrocochleography elicited by an electrical stimulation on the promontory

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Background
Electrical stimulation of the cochlea can elicit an electrical potential travelling in the auditory pathway. This electrical evoked potential can be recorded by a recording setup of EABR, and using at the same time

trans tympanic electrical stimulation (TT-EABR). Using the electrical stimulation to the cochlea, and recording evoked potential with a 10 ms time window, it is possible to see if the electrical potential travels in the auditory pathway, up to the brainstem. The response, evaluating by the amplitude/latency of the waves, can be used to decide whether proceed with cochlear implantation, since with this method it can test the integrity of the auditory pathway, essential to get benefit of the use of cochlear implant.

Objectives
The goal of the study was to develop such testing system using the CI fitting system of MED-EL (Innsbruck, Austria). An electrical stimulation to the promontory is applied and an Electrocochleography is recorded. The evaluations of the results are given by the presence or absence of an electrical response in the cochlea within 6 ms from the applied stimuli.

Methods
For the stimulation, a transtympanic electrode is placed through the tympanic membrane on the promontory of the cochlea. The stimulation is generated by using the Detector Box from MED-EL and configured using the EABR task of the Maestro. Current level and other parameters included number of pulses, stimulation rate and pulse characteristics are specified. For the recording, an EP recording device connected to the PC is used. A detailed set-up will be described.

Results
To this date, we were able to record TT-EABR in 4 patients. Based on obtained responses it was decided whether the patient was implanted with cochlear implant or not.

Conclusion
The initial data suggest that this tool may be very useful in difficult cases when it is not clear if patient benefited from cochlear implant or not. A further work is needed.

P23

Difficult decisions in Cochlear implantation

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No conflicts of interest

Objectives
To Study the factors that can help in deciding whether to implant in a given case and if so which ear? Whether these factors were predictive of prognosis.

Background
In the course of Cochlear implantation we do face situations when decision making becomes a dilemma. The factors considered so as to overcome these situations and implant these children after informed decision making by parents and work towards favourable outcomes are given.

Methods HRCT & 3 Tesla MRI with different cuts, EABR and Early speech perception and Pattern perception tests were used in making decision whether to implant and if so which ear in three unique cases. Also parent expectations were considered in this process
1) Waardenburg's Syndrome - child was denied cochlear implant due to improper scanning and reporting.
2) Child with double internal auditory canals but cochlear nerve not identifiable.
3) Child with Cardiac anomaly, Laryngomalacia along with Hypo plastic Cochlea and Cochlear nerve.

Results
Aq. 6years post-implant has developed good speech and language and goes to normal school. Sdt. with Bimodal hearing was re-implanted one and half year back due to Device failure. Presently she is attending normal school. Gr. Implanted just 3 months back picked up listening skills in consistent with her implant age though she still has a feeding Gastrostomy and Tracheo-cutaneous fistula.

Conclusions
Careful detailed evaluations of problematic cases along with diligent counselling of parents about expectations go a long way in decision making regarding implantation and getting favourable outcomes.

P24

Test Battery Approach Toward Candidacy for Auditory Brainstem Implantation - Indian Perspective

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Objectives
To highlight the approach in patient assessment to obtain the right candidates for Auditory Brainstem Implantation

Methods
12 subjects were intitally considered for ABI. All followed a planned candidacy selection pathway through test battery approach. Of these, ten had significant cochleovestibular malformation with a hypoplastic VIIIth cranial nerve on MRI. Of the other two, one had completely ossified cochleas and the other had bilateral vestibular schwannomas (NF2).
The subjects underwent detailed imaging and audiological assessment that included high resolution 3T MRI, CT scans and complete audiological evaluation. Of the twelve subjects, the ten with Cochleovestibular anomaly and hypoplastic auditory nerve further underwent TTEABR as part of the test battery. The last two were not considered for TTEABR as this investigation was not indicated.

Results
Following the positive result from TTEABR in the seven of the ten subjects the option of cochlear implantation was reconsidered. One child was deemed unsuitable for CI due to extremely hypoplastic cochlea and thus underwent ABI. The other six children underwent successful Cochlear Implantation. The three children with no response on TTEABR underwent ABI. Thus eventually six of the twelve cases (50%) underwent successful ABI surgery and the other six reeived a CI.

Conclusions
It is mandatory to have a stringent test battery approach in evaluating ABI candidacy, as similar outcomes may be achieved through CI itself and can save the tedious process of ABI implantation. However, the long term outcomes in all these implanted cases are subject to continued evaluation over time.

P25

Inter-Aural Attenuation as a Predictor of Outcomes for SSD Patients Implanted with the Bonebridge

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Objective:
The aim of this study is to determine if inter-aural attenuation is a predictor of outcomes for patients with sensori-neural single-sided deafness (SSD) who have been implanted with the Bonebridge. Our hypothesis is that SSD patients with less inter-aural attenuation will have greater improvements in signal to noise ratio and functional gain.

Background:
The Medel Bonebridge is an active, semi-implantable bone-conduction auditory prosthesis, indicated for patients with conductive or mixed hearing loss, as well as for SSD. The Bonebridge helps to overcome the Head Shadow Effect by transferring sound from the deaf ear to the better hearing ear; this transfer of sound can provide improvements in signal to noise ratio as well as functional gain on the deaf side. A test that is predictive of these improvements would be useful in determining candidacy for Bonebridge implantation for SSD. The current study will discuss findings and explore any emerging trends.

Methods:
The 6-month outcomes of 5 patients with SSD implanted with the Bonebridge will be presented, in addition to preliminary results for 5 newer SSD patients.
All patients underwent pre-operative and post-operative testing including air and bone conduction audiometry in pure tone and speech, inter-aural attenuation measurements and measures of functional gain in soundfield from 250Hz to 8000Hz. Inter-aural attenuation is a simple measure of the reduction in sound intensity as it transfers from one side of the head to the other. Signal to noise ratio was measured using the Adaptive Hearing In Noise (HINT) test and was completed at 0, 90, and 270 degrees with noise presented at 0 degrees.
Data from the Health Utility Index Mark 3 (HUI-3), the Speech, Spatial and Quality of Hearing Scale (SSQ), the Tinnitus Handicap Inventory (THI) and the Bern Benefit in Single-Sided Deafness questionnaire (BBSS) will also be presented, as they relate to the inter-aural attenuation and functional gain measurements.

Results:
Analyses for 5 patients will include inter-aural attenuation measures in relation to signal to noise ratio and functional gain in soundfield, collected at 3 timepoints; pre-operatively, and 1 and 6 months post-activation.
Additional analyses will be presented for 5 newer SSD patients, including these same aforementioned measures at 2 timepoints; pre-operatively and 1 month post-activation.

Conclusions:
These results will be instrumental in determining whether inter-aural attenuation measures are predictive of signal to noise ratio and functional gain in SSD patients implanted with the Bonebridge.

P26

Electrode migration in patients with perimodiolar electrode arrays

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Introduction
Cochlear implantation is a safe procedure with a low risk for major complications. Migration of the electrode is associated with vertigo, tinnitus, low speech perception and nonauditory stimulation, but is a rather uncommonly complication. So far it was only obsered in lateral wall electrodes. The aim of our study was to detect electrode migration by comparing postoperative insertion depth angle with the insertion depth angle after surgery of the second side in patients with perimodiolar electrode arrays.

Material and methodes:
Between 1999 and 2013 59 patients underwent bilateral cochlear implantation in our institution. Most of the patients received perimodiolar electrode arrays (Nucleus Contour, Contour advance, Helix). 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 postoperative scans performed after the second side surgery.

Results:
In 40 patients radiologic images were evaluable and the insertion depth angle was estimated. The mean timeframe between surgeries was 24 month. 6 patients were detected with a electrode array migration of more than 20°.

Discussion:
In our population migration of the electrode array was seen in 15% of the patients. Fixation of the electrode array is required to avoid electrode migration even in perimodiolar electrodes. Electrode migration in perimodiolar electrodes seems to be less frequent and to a lower extent than in lateral wall electrodes.

P27

Intracochlear pressure changes due to round window opening – observations in a model

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Introduction
The indication criteria for cochlear implantation have been changed over the last years. Due to new techniques the indication for cochlea implantation has evolved to patients with residual hearing. To preserve residual hearing the electrode design has changed and the atraumatic insertion of the cochlea electrode has moved into the interest of cochlea implant research. The aim of our study was to observe intracochlear pressure changes due to different openings of the round window in a cochlear model.

Material and methodes:
Round window openings were performed in an artifical cochlear model. Intra cochlear pressure changes were estimated by a micro-optical pressure sensor which was placed in the helicotrema area. Openings of the round window membrane were performed by a needle, a canula, a diode laser and a CO2 laser. Additonally temperature changes were evaluated by a fiber optical sensor.

Results:
Statistically significant differences were seen between the different ways of the opening of the round window membrane in regard of the intracochlear pressure changes. Lowest pressure changes were seen by opening the round window membrane with the diode laser. Similar pressure gain were seen due to opening of the round window membrane by the needle and the canula. The opening with the CO2 laser showed a high negative intracochlear pressure and loss of intracochlear fluid. Temperature changes were insignificant.

Discussion:
The atraumatic approach to the cochlea is assumed to be essential for the preservation of residual hearing. In our model experiments we could compare objectively different ways of opening the round window membrane by the estimation of intracochlear pressure. The influence on intracochlear trauma remains unclear since several more factors, e.g. electrode design, insertion depth, insertion speed, have to be considered aswell.

P28

Poster Withdrawn

P29

Binaural Fusion and Listening Effort in Children

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Objectives
We aimed to identify functional advantages of early bilateral cochlear implantation in children.

Background
Bilateral cochlear implants (CIs) have been provided to children to promote binaural hearing and perhaps limit the listening effort experienced by unilaterally implanted children. However, it remains unclear whether bilaterally implanted children have access to accurate binaural cues.

Methods
Forty-nine children participated: 25 were deaf and received bilateral CIs and 24 had normal hearing. All children participated in a behavioural binaural integration task. To measure effort, the change in pupil diameter was calculated relative to baseline values, using a Videonystagmography system. Reaction times were also measured and auditory brainstem responses were previously measured in the CI users.

Results
Bilateral cochlear implants promote integration of bilateral input when level cues are present. Poorer integration translates into greater effort, as measured by increases in reaction time ($R=-0.41$, $p<0.005$) and pupil diameter ($R=-0.74$, $p<0.001$). Variability in integration without level cues is explained in part by asymmetries in auditory brainstem function and by the age at CI-1 ($R=0.59$, $p<0.05$). Children who received their CIs at older ages had better low-frequency residual hearing ($R=-0.89$, $p<0.001$).

Conclusions
Bilateral implantation allows children to integrate bilateral input when differences in interaural level are present. Reaction time and pupil diameter indicate greater effort in children who perceive one image less frequently. Integration without level cues is better in children who received their first CI later, which may

be due to a longer period of acoustical hearing prior to implantation. Auditory brainstem asymmetries may underlie poorer integration.

P30

Intraoperative ECAP in patients with long time of hearing deprivation

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Objectives
To identify differences between intraoperative electrical evoked compound action potentials (ECAP) in patients with > 10 years and < 5 years of durations of deafness.

Background
Patients with longer duration of deafness may have worse prognosis due to possible ganglion cell survival and deafferentation. Is the presence of intraoperative ECAP a positive prognosis predictor in these cases?

Methods
Adult, post lingually deaf, were randomly selected. Exclusion criteria included bilateral implanted, incomplete electrode insertion, neural etiologies, meningitis and malformed cochleae. They were divided into two groups according to deafness duration: GI: > 10 years and GII: <5 years. Intraoperative ECAP in at least three electrodes and speech perception performance after 1 year of device use were compared.

Results
The sample was 54 patients, 26 patients implanted with Nucleus 24RE (Cochlear) and 28 implanted with Sonata TI100 (Medel) devices. 47 patients (89%) showed present intraoperative ECAP. Among the Nucleus implanted patients with present intraoperative ECAP (GI = 12, GII = 11), 58% of GI and 79% of GII showed > 80% of open set recognition. Among the Sonata implanted patients with present intraoperative ECAP (GI = 9 and GII = 15), 63,6% of GI and 81,3% from GII presented > 80% of open set recognition.

Conclusions
Patients over 10 years of deprivation showed present intraoperative ECAP suggesting ganglion cell survival. However their performance in speech recognition after 1 year of CI use, was lower than those who had shorter time of auditory deprivation, suggesting auditory central nervous system deprivation.

P31

EABR Measures in the Pediatric Non-NF2 Population

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Objectives
To determine the stability and predictive value of intraoperative EABR in children without neurofibromatosis (NF2) receiving an auditory brainstem implant (ABI).

Background
The ABI is an electronic device designed to convert acoustic sounds into electrical impulses that are delivered along a multiple electrode array situated in close proximity to the cochlear nucleus in the brainstem. To date, the majority of recipients have primarily been over the age of 11 deafened by NF2 with mixed results. Recently, the ABI has been implanted in patients without NF2 who were deafened by the loss of function of the auditory nerve/cochlear due to a variety of etiologies.

Methods
4 children ages 21 months-17 years with absent auditory nerve or cochlear deficiencies underwent ABI surgery with the Nucleus 24M ABI device. Intraoperative EABR recordings measuring P1 latencies using the Interacoustics Eclipse EP system and the Cochlear Custom Sound EP software were obtained and repeated at the time of device activation. Initial measurements used a wide bipolar mode followed by narrower electrode pairs. Where a response was obtained, the polarity was reversed. Age appropriate measures of speech perception were administered postoperatively.

Results
All children underwent successful ABI implantation with no complications, are full-time users and obtain varying amounts of closed set speech understanding with/without visual cues. Although preliminary analyses have not revealed a correlation between performance and intraoperative/postoperative P1 latencies some trends exist.

Conclusions
The ABI appears to provide auditory awareness in children without NF2. Further research is needed to determine predictability of factors.

P32

Improvements in intraoperative objective measurements – the CR220 Intraoperative Remote Assistant

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Objectives
To evaluate usage of the new CR220 Intraoperative Remote Assistant. To understand the clinical impact of using a wireless handheld device to make intraoperative diagnostic measurements and to investigate whether it is possible for other operating theatre personnel to perform these measurements.

Background
Intraoperative electrode impedances and ECAP threshold measurements are commonly performed to increase confidence for the surgeon, audiologist and recipient of correct positioning of the electrode array and correct functioning of the cochlear implant. The CR220 performs these measurements wirelessly with only a sound processor in the sterile field, without a computer. Less equipment and time should be required for an experienced audiologist, and potentially a less experienced person may be able to perform the same measurements.

Methods
Clinicians in 16 clinics were trained to use the CR220, and used it in 63 cochlear implant surgeries. They logged each session and answered a final questionnaire, including questions on clinical practice and usability.

Results
The CR220 reduced the time spent by the clinician in surgery. It was found to be easy to use, and to give the same level of confidence in the outcome compared with the existing method. Furthermore it was confirmed that non-audiologically trained staff could use it instead.

Conclusions
The CR220 is a new tool which will improve the efficiency of clinical practice for clinicians. It is more convenient while giving the same level of confidence during surgery. It also provides for other operating theatre personnel to perform measurements, achieving the same level of confidence.

P33

Improving a Computational Model of a Cochlear Implant

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No conflicts.

Objectives
We aim to develop a clinical tool that predicts two qualities of the electrode-neuron interfaces of a cochlear implant from psychophysical data: the electrode-neuron distance and the local neuronal viability.

Background
A number of perceptual measures in cochlear implant listeners, such as threshold and psychophysical tuning curves, have been shown to vary substantially from channel to channel. A computational model was developed in our laboratory to explain this variability in terms of the electrode-neuron interface. Results with the model suggest that a poor interface for an implant channel can occur when the electrode is far from the spiral ganglia and/or the condition of the local auditory nerve is poor. We recently obtained CT imaging data which will potentially validate the model output

Methods
Psychophysical threshold data and electrode position data from CT scans from 5 subjects were programmed into a computational model of a 16-electrode implanted array . A least-squares fitting algorithm predicted the viability of local neurons.

Results
The model initially failed to fit the psychophysical threshold and CT data. The fit was substantially improved by incorporating local impedance variability near cochlear locations for which the CT images suggested the electrode array breeched the membranous cochlear partition. A scanning procedure devised to detect the location of a breech was accurate to within 2 mm for 4 of 5 subjects.

Conclusions
Cochlear tissue damage near compartmental breeches may manifest as regions of high impedance. This is worth considering in future modeling endeavors and as a predictive, non-invasive tool for monitoring the integrity of an implant array.

P34

The assessment of the scalar position of the HiFocus Mid Scala electrode based on MRI and Cone Beam CT fusion

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Authors are employees of Advanced Bionics.

Objectives
The aim is to investigate the scalar position and the potential for preserving the residual hearing with the HiFocus mid scala electrode in a group of newly implanted CI users receiving the AB Advantage implant.

Background
One of the contributing factors to the variability in outcomes amongst CI recipients was reported to be the placement of the electrode array in the scala tympani. Studies comparing speech perception results for patients with different electrode placement, are showing that the best results were obtained after insertion into the scala tympani, poorer results after dislocation from scala tympani to scala vestibuli, and poorest results after insertion into scala vestibuli.

The HiFocus mid scala electrode was developed to cover one and a quarter turn and with the pre-curved design to be less susceptible to variations in individual cochlea dimensions and insertion techniques.

Methods
In a multicentric prospective study design a group of adult Advantage HiFocus Mid Scala implanted subjects the scalar location and the insertion depth of the electrode will be investigated. Shortly after the CI surgery obtained Cone Beam CT images will be fused with the pre-operative MRI and analyzed for the electrode position. The level of residual hearing and speech performance will be monitored and correlated with the scalar position of the electrode.

Results
Up to date five patients were implanted and have undergone initial assessments. In three a scala tympani insertions were achieved and in two a dislocation of the electrode array into scala vestibuli has occurred. The reason for dislocation were found to be a sclerotic connection between the two scalae in one subject and presence of fibrosis at the entrance of the cochlea in other.

Conclusions
Further subjects and results will be discussed and presented.

P35

An objective method for measuring forward masking functions with the cochlear implant

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This work was funded by a Research Grant from Cochlear AG, Switzerland.

Abstract
An objective method to measure Forward-Masking functions will be presented. The results comparing these objectively versus psychophysically measured Forward Masking functions, as well as their corresponding Spread of Excitation functions from 10 Cochlear Implant subjects will be discussed.

Background
The Spread of Excitation (SoE) function typically involves a stationary Probe stimulus, while the Masker location is varied along the electrode array. Additionally, the Probe and Masker stimulation levels are held constant throughout the measurement series. It is often assumed that the SoE function is similar to psychophysical Forward Masking functions and give an indication of the stimulation selectivity. However, it is argued here that the SoE function series as it is currently implemented provides only rudimentary estimates of the stimulation selectivity, and similarities to psychophysical Forward Masking functions are therefore only approximate.

Methods
An alternative and objective method of measuring the Forward Masking function will be presented. This procedure closely resembles the methodology of psychophysical Forward Masking function measurements in that the Masker is kept constant and stationary, while the Probe is varied in level as well as location. Firstly, it is assumed that inadequate forward masking also would mean that the Probe is perceptible. Secondly, inadequate forward masking also leads to ECAP measurements with smaller than expected response amplitudes. Combining these two premises, it is possible to then derive a series of measurements which can detect the point at which inadequate Forward Masking occurs. This point is then assumed to be equivalent to the Probe detection threshold and the data used to construct an objectively measured Forward Masking function.

Results and Discussion
Data from 10 Cochlear Implant subjects are presented, comparing Forward Masking threshold functions measured objectively as described above, as well as measured psychophysically. In particular, the corresponding SoE functions for these 10 patients are also examined to see how they compare to the corresponding Forward Masking functions. The implications of these results will be discussed.

P36

Electrocochleography to Auditory Stimuli in Cochlear Implant Subjects: An Overview

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Research support from MED-EL, Cochlear Corp, and Advanced Bionics.

Objectives
To describe intraoperative electrocochleography from the round window as well as from within scala tympani in cochlear implant patients.

Background
Electrocochleography (ECoG) obtained from the round window and from within the cochlea might be a useful tool to monitor electrode insertions in real time in the operating room during cochlear implantation. Further, it might help to estimate the neural substrate for electric stimulation and thus predict cochlear implant outcomes.

Methods
Extracochlear responses to sounds were recorded at the round window of cochlear implant subjects, both adults (n=75) and children (n=78). Acoustic stimuli were presented across various frequencies. A level series was taken at one frequency (usually 500 Hz) to determine thresholds.

Results
Nearly all (>95%) cochlear implant subjects have responses to tones significantly above noise levels for one or more frequencies. The range of response magnitudes to the same sound pressure vary by nearly 60 dB, from ~0.1 µV to 100 µV. The frequencies that contribute are typically 1000 Hz and below, with the response to 250 and 500 Hz predominating within this range. There is relatively high predictability (~30% for children and ~45% for adults) between response magnitude and speech score outcomes in our sample.

Conclusion
The response to sound is an easily obtainable and useful measure of cochlear function. It is the first measure of cochlear health that shows a high degree of correlation with subsequent outcomes. It could also be a baseline measure used to monitor cochlear status during the implantation.

P37

Radiological results and hearing preservation with the CI422 Straight electrode via round window versus cochleostomy approach

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No conflicts.

Objectives
To evaluate the potential influence of 2 different cochlear implant (CI) electrode approaches to the scala tympani in terms of insertion depth and angle as well as hearing preservation.

Methods
We performed a retrospective analysis of 41 adult subjects that underwent cochlear implantation with the attempt of atraumatic electrode insertion and hearing preservation. Radiological assessment of insertion depth and angle was performed on postoperative rotational tomography. Postoperative acoustic hearing preservation and speech perception in quiet measures were obtained in defined intervals and compared for both groups

Results
14 subjects were implanted using a cochleostomy and 27 via a round window approach. Mean insertion depth amounts to 21.5 mm (SD=1.1) while mean insertion angle revealed to 388° (SD=34.7) for all CI-recipients with no significant difference between the cochleostomy and the round window group. Radiological evaluation of electrode placement revealed 82.9% scala tympani insertions, 14.6 % dislocations from scala tympani to scala vestibuli (as well in cochleostomy and round window approaches) and no (0%) primarily scala vestibuli insertions.
The audiological data so far demonstrate no significant difference in postoperative outcomes for both CI-aided speech perception and preservation of residual hearing between the cochleostomy and the round window group.

Conclusions
The CI422 straight electrode enables hearing preservation by using a cochleostomy or round window approach without significant differences if insertion depth is at 21.5 mm. Nevertheless, scalar dislocations might occur in both approaches at a low rate demanding further improvement of electrode design. Surgeons should be trained to perform both a soft-surgery cochleostomy and round window access as the round window niche is not always accessible due to anatomical reasons.

P38

Importance of Apical Stimulation in Cochlear Implantation

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By the application of markers, an attempt was made to demonstrate the importance of the apical region of the cochlea in relation to the discriminative complexity of the language, hearing in noisy situations and musical perception. Our observations with HRP (Horseradish peroxidase) and Cajal-de Castro stain are presented. The results of 32 cases implanted with MED-EL Cochlear Implants and a comparative study with standard electrodes are also included. Using this method, we try to demonstrate the improvement of speech perception in noisy environments and a more natural hearing quality.

P39

A 3D model-based Simulation of the Electrical Field during Cochlear Stimulation

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This work is partly funded by the ANRT and Neurelec / Oticon Medical.

Objectives
Obtain an accurate description of the spread of excitation for different stimulation patterns and electrode array layouts.

Background
The speech performance of cochlear implant patients is known to plateau as the number of stimulating channel increases. This is mainly hypothesized to originate from current spread. Indeed, when electrically stimulating the nerve fibers from the electrode array, the diffusive tissue between them causes a spread of excitation and the waste of the stimulating current.

Methods
A parametric 3D mesh model has been designed to represent the geometry of the cochlea. Using spline interpolation, this model can be easily fitted into the existing parametric descriptions or biomedical images of the cochlea of different species. The computation of the electrical field is achieved through the boundary element method (BEM) by using the OpenMEEG software. This software has already been widely adopted in solving the forward problems related to EEG/MEG and has excellent accuracy.

Results
Stimulation current is described as the boundary condition on the mesh surface of the electrode array. We obtain a quantitative description of electric field within the cochlea produce by different stimulation patterns. These simulation results are compared to the electric potential measured at different locations inside the cochlea. Recorded data are collected along the electrode array and along the central axon of the nerve VIII.

Conclusions
Thanks to its accurate description of different cochlear geometry and stimulating current, this simulator will allow sensitivity analysis of the variability of cochlear and electrode geometries. This will provide valuable references for the design of future personalized cochlear implants.

P40

A Comparison of Alternating Polarity and Forward Masking in Cochlear Devices

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This research was funded by grant # R01 DC009595, NIH, NIDCD

Objectives
The goal of this study was to examine ECAP growth function threshold, amplitude, and slope using forward masking (FwdMsk) and alternating polarity (AltPol) artifact-reduction techniques.

Background

Manufacturers utilize different artifact rejection methods when obtaining amplitude growth functions (AGFs) in the clinical software. Previous studies have compared AGFs using FwdMsk and AltPol in Advanced Bionics devices and found lower amplitudes, shallower growth functions, and lower or equivalent linear regression thresholds utilizing AltPol. To our knowledge, no study has been published that compares these two methods in Cochlear devices, which utilize FwdMsk as the default in the clinical software (Advanced Bionics uses AltPol). The purpose of this study was to compare amplitudes, slopes, and visual-detection thresholds using FwdMsk and AltPol in Cochlear devices.

Methods
ECAP AGFs using both FwdMsk and AltPol were obtained from 26 ears: Nucleus CI24R (N=6), Nucleus CI24RE (N=12), and Nucleus CI512 (N=8).

Results
AltPol waveforms could not be resolved for the 6 CI24R recipients. Data analysis comparing FwdMsk and AltPol in the 20 newer-generation devices showed no significant difference in amplitude or slope (amplitude: $p = 0.30$; slope: $p = 0.48$). Median group thresholds were significantly lower ($p = 0.005$) for the FwdMsk method (166 CL) than the AltPol method (175 CL).

Conclusions
Improved morphology with AltPol is observed with newer-generation Cochlear devices due to an improved amplifier. Even with the improved amplifier, our data showed lower visual-detection thresholds with FwdMsk than AltPol suggesting that FwdMsk is the more optimal artifact-reduction method for Cochlear devices.

P41

Progress in the development of a digital cochlea stimulation and evaluation tool (DiCoStET).

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A computational model was developed to give an objective estimate of cochlear implant performance based on neuronal activation measures, such as vector strength and average activation. A human cochlea 3D geometry is generated using a model that is driven by a single distance measurement from a patient, using non-intrusive HRCT, and human anatomically invariant metrics and relations. An innervation pattern of neurons populates, in the anatomically correct trajectory for humans, the space between the organ of Corti to the spiral ganglion and then descenting into an auditory nerve bundle. An electrode is inserted in the scala tympani at a depth that is determined by the user. The geometric relation between the stimulation sites on the electrode and the spiral ganglion are used to estimate an activating function which will be unique for the patient cochlear shape and electrode placement. A cochlear implant stimulation model is developed which allows the use of various sound processing tools, and allows estimation of electrical current generation at each stimulation site based on the incoming audio signal. A pure tone experiment was performed where sound snippets of one second in duration, varying loudness and ranging in frequency between 100 Hz and 8 kHz, were used to stimulate a collection of 10000 auditory nerves. Novel stimulation error techniques, namely Absolute Synchronisation Error Measure (ASEM) and Absolute Relative Activation Error Measure (ARAEM), are used to estimate if asymmetry in the filter-bank response resembling the filtering action of a single point in the basilar membrane is a better performer than a symmetric filter-bank. The results indicate that the asymmetric filter-bank generates a more natural activation pattern, but both techniques are very poor in conveying the correct timing of pulses. This is most probably caused by the fact that in both cases a fixed rate interleaved stimulation strategy was used.

P42

Optimizing EEG electrode number and locations for a simple clinical application of ASSR measures: a computational approach

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Background
Auditory steady state responses (ASSR) have been proven to be a relevant objective measure of the auditory behavioral thresholds as they are well correlated with the electrophysiological loudness growth function in normal-hearing adults. However, these neuronal responses are always submerged in the cochlear implant's (CI) stimulation artifacts when elicited electrically in implanted patients. In this context, at least 7 EEG electrodes remain inevitable to guarantee an acceptable extraction of the electrically evoked ASSR (Hofmann & Wouters 2012).

Objectives
This study aims at 1) minimizing the number of EEG electrodes required to denoise the recorded signals 2) by optimizing their respective locations.

Methods
In this perspective, an EEG computational model implementing the generation of the CI stimulation artifacts and neuronal responses as well as background EEG activity is proposed. This boundary element method (BEM)-based model uses the MNI (Montreal Neurological Institute) generic head model to estimate the diffusion of the CI artifact over the modeled voxels as well as that of the evoked ASSR dipole in the auditory cortex. For extracting the simulated response, an independent component analysis method (Infomax) is adopted given its reported efficacy. The choice of n electrodes is optimized for this study (n = 5).

Results
The results reveal the optimized electrode locations for a simplified five-electrode recording setup.

Conclusions
In perspective, different n-electrode recording setups will be accomplished and the clinical validation of the optimal setup will be performed.

P43

Teaching tool for advanced visualization of temporal bone structures by fusion of microCT and CT scan images

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Objectives
To enhance understanding of human temporal bone computed tomography (CT) scans based on semi-automatically segmented microCT.

Background
The three-dimensional ear anatomy is complex and challenging to interpret in CT scans because small structures are partially invisible. Histological slices provide complementary high-resolution information, but may lead to geometrical distortions of the anatomy during preparation. Conversely, MicroCT preserves the shape of structures and the composition of soft tissues with a simpler acquisition protocol.

Methods
Images of five freshly harvested cadaveric pairs of temporal bones were acquired using both CT and microCT scanners. MicroCTs were semi-automatically segmented using a seed-based segmentation algorithm. The delineated structures of interest include the cortical and trabecular layers of the entire temporal bone, the vestibular labyrinth with the scala tympani and vestibuli, the ossicles and their ligaments, the tympanic membrane, the middle ear muscles and tendons, the internal carotid artery, the different branches of the vestibular nerve, the facial nerve and the corda tympani. Rigid registration between microCT and CT images was performed.

Results
High resolution structures are fused and visualized on corresponding CT images. Transparency of anatomical structures can be controlled individually. This experience significantly improves the visual recognition and spatial understanding of partially visible structures (e.g. facial nerve and chorda tympani) in CT images.

Conclusions
Geometrically accurate temporal bone reconstructions provide an advanced teaching tool for medical students and cochlear implant surgeons. The understanding of spatial relationship between anatomical structures as well as the virtual exploration of surgical approaches is greatly facilitated.

P44

Variations in Microanatomy of the Human Cochlea

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Background The human cochlea shows considerable interindividual variability in size and morphology. In order to developatraumatic cochlear implant (CI) electrodes, high-precision details of the variability of human anatomy are required. Methods Sixteen human temporal bones were cut around the cochlea in blocks of approximately 3.5 x 3.5 cm. The bones were scanned using a Skyscan 1173 micro-computed tomography (µCT) device. ‘Materialise MIMICS’ software was used to segment out the ST from the µCT images. A three-dimensional surface model of the segmented area was generated for each cochlea.

Cross-sectional images were taken and analyzed by custom-designed software in MATLAB. Results Comparison of different ST showed large variability in cross-sectional diameter (CSD), vertical trajectory, and height of the ST. Relative standard deviations of the CSD are between 9 and 15%. Heights measured at the center of the ST exceeded those in the modiolar and lateral region of the scala. At the lateral region, the height decreases significantly at the beginning of thesecond turn. In the vertical trajectory, critical anatomic features were observed, such as dips, vertical jumps, and peaks. Rosenthal's canal (RC) extended to between560 and 650 degrees. Conclusion We found a correlation between the length of the RC and that of the ST. The ST was segmented and the internal dimensionsmeasured using µCT. We observed large dimensional variability between different ST. These differences could have considerable implications for approaches to thedesign of CI arrays, especially in terms of their capability to preserve residual hearing during insertion of the electrode array.

P45

An Objective Assessment of Partial Tripolar Stimulation

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All authors are employees of Advanced Bionics, LLC

Objectives
Use objective measures to better understand and assess the potential benefits and inter-subject variability of partial tripolar stimulation.

Background
Monopolar stimulation produces wide current spread, limiting the number of independent channels. Partial tripolar stimulation has the potential to reduce current spread, thus increasing the number of independent channels, which in turn may lead to improved speech understanding. However, studies investigating partial tripolar stimulation have reported variable outcomes in speech perception and psychoacoustic tasks.

Methods
To objectively quantify the effects of partial tripolar stimulation, we measured electric field imaging in 10 cochlear subjects using monopolar and varying levels of partial tripolar stimulation. Spectral ripple discrimination was also measured in the same 10 subjects.

Results
As reported in many studies M-Levels for partial tripolar stimulation were significantly higher than for monopolar stimulation. When the electric field imaging data was scaled to the corresponding M-Level, we found significant variability in the field spread on different electrodes and in different subjects. In general, partial tripolar stimulation decreased electric field spread when compared to monopolar stimulation. However, in a significant number of electrodes and subjects, partial tripolar stimulation produced either a similar or a broader electric field, when compared to monopolar stimulation. Correspondingly, only 6 of the 10 subjects showed an improvement in spectral ripple discrimination task with partial tripolar stimulation.

Conclusions
These electric field imaging results may explain some of the variability in subject performance noted with partial tripolar stimulation.

P46

Different modalities of eCAP measurements using the VOLTA software: Initial clinical experience

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Objectives
To assess different paradigms of VOLTA for recording eCAPs in the clinical routine.

Background
The use of neural response thresholds and eCAP measurements for predicting behavioral measurements have been largely discussed in the past two decades. While group data is reported to show some comparable correlations between different studies, the variance is indicative for individual deviations from the average. However, it may lead to potential over- or under-stimulation in CI users if the psychophysics were rigidly set based on neural telemetry data. On the other hand the fitting of young children may be challenging to a level where objective measures are the only short term feedback on the stimulation of the auditory system. Understanding the factors associated with individual deviations of eCAPs in CI users are key element of today's research. Advanced Bionics has recently launched a software platform VOLTA for measuring different paradigms of eCAPs. VOLTA is designed to allow fast, intuitive and flexible mode of measuring, tNRI, growth functions and spread of excitation in fully manual or automated manner.

Methods
In adult users implanted with AB CI, measurements of tNRI and slopes using the Express-NRI feature and the spread of excitation will be performed using VOLTA during CI surgery and at initial follow up fitting sessions.

Results
Measurements of tNRI, loudness growth and spread of excitation using automated algorithms in VOLTA will be compared to the psychophysical data and discussed.

P47

Wave propagation in the skull bone during bone conduction stimulation

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Background
Bone conduction (BC) hearing aids are used for patients with conductive or mixed hearing losses who cannot wear conventional hearing aids, or for patients with single sided deafness. Some BC hearing aids stimulate the skull directly, while others are placed on the skin covering the skull. The latter way of stimulation is also used as preclinical assessment of BC hearing aids and to determine BC hearing thresholds. The propagation of skull-bone vibration with different modes of stimulation may vary. This study aims to investigate the wave propagation in the skull bone during bone conduction stimulation, for different stimulation sites and stimulation modes.

Methods
Measurements were performed in three human cadaveric whole heads. A bone anchored hearing aid

(BAHA) was attached to a percutaneously implanted screw or positioned with a steel headband at two positions (mastoid and forehead) using a static force of 5 Newtons. The stimulation force with the two interfaces was calibrated using a skull simulator (bone) and an artificial mastoid (skin). Two stimulation signals were used: (1) a stepped-sine signal in the frequency range of 0.1 – 10 kHz for measurement in frequency domain, and (2) a two-cycle sine signal at frequencies between 0.5 and 8 kHz for measurements in time domain. Simultaneously, skull bone vibrations were measured at multiple points on the skull using a Laser Doppler Vibrometer system.

Results
While the magnitude of the transferred force was similar for both the BAHA “coupled to the screw” and “positioned with the headband”, the phase with “positioned with the headband” showed larger phase delay than with “coupled to the screw” above 1 kHz. Skull bone vibrations showed near rigid-body motion at low frequencies below 0.5 kHz, and clear traveling waves were observed at high frequencies above 2 kHz, for both conditions. The speed of wave propagation was of a similar magnitude and only the direction of the wave propagation changed for the two stimulation sites. Significant attenuation with distance from the bone vibrator was not observed.

Conclusion
Stimulation on the skin covering the skull seems to be a reasonable way of preclinical assessment of BC hearing aids directly attached to the skull in regard to wave propagation. The propagation speed was similar without attenuation of the magnitude for the two stimulation sites of the mastoid and the forehead.

P48

An Additive Instantaneously Companding Neural Readout System for Cochlear Implants

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Objectives
Development of a single chip, low noise, high bandwidth and power efficient readout system for neural responses in cochlear implants.

Background
The recording systems used for reading out the evoked compound action potential (eCAP) in existing cochlear implants are restricted due to the occurrence of saturation in the single channel amplifier and analog to digital converter (ADC), and the relatively high internal noise levels. Consequently, eCAPs are generally recorded at the upper end of the subjective electrical dynamic range, which limits the clinical relevance of these measurements.

Methods
An overall readout system design is proposed containing an additive instantaneous companding input system that is able to record the eCAPs from the stimulated auditory nerve with a 126 dB dynamic range, thereby covering both stimulus artefact (up to 20V) and the neural response (down to 10μV).

Results
The first generation of the chip was hampered by the external control system. Currently the second chip is being evaluated. The system functions well under various wave forms. The rate of operation is still limited due to the external control chip (bandwidth up to approximately 15kHz). The maximum amplitude change that can be followed is now 0.5 V per 1.2 μs. Animal experiments in guinea pigs are underway.

Conclusions
The readout system is showing promise to reach its set targets. The limitations due to the external control chip will be resolved in the third generation that will fully integrate the companding and control systems in a single design.

P49

Automated electrically evoked compound action potential (eCAP) screening with Express-NRI: method validation

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This study was sponsored by Advanced Bionics.

Objectives
Validate Express-NRI by comparison to regular eCAP measures.

Background
Efficacious clinical use of electrically evoked compound action potentials (eCAPs) requires the measurements of auditory nerve (AN) response to electrical stimulation to be supported by a straightforward and flexible interface. Automated Express-NRI is a feature of the research objective measure software VOLTA, that allows screening automatically AN dynamic range and spatial excitation function with eCAPs. Express-NRI follows a context-dependent algorithm that sets recording and stimulation parameters to optimally measure growth and spread of excitation (SOE) functions as quickly as possible. eCAPs with an amplitude greater than 50 μV and an SNR greater than +5dB are automatically recognized as 'containing a neural response'. In addition, VOLTA reuses invariant responses within each sweep. Finally, stimulation currents are set based on loudest tolerable level in order to swiftly obtain four recordings having a true neural response or alternatively skip to the next sweep.

Methods
In a first batch of 9 patients, Express-NRI over the whole array was compared to the regular Growth-MP with 6 points and also to the regular SOE at 4 electrode locations.

Results
By using Express-NRI, the threshold estimation for a complete array completed in an average of 8 min 52 (34 s/contact). In 36 s/contact, the Growth-MP only obtained 1 measureable threshold. Express-NRI identified conditions with no measureable eCAPs and completed threshold measurements faster than Growth-MP.

Conclusions
Growth-MP requires more points and thus longer measurements to obtain thresholds than Express-NRI. Express-NRI enables optimized threshold measurements.

P50

Adequacy of audio processor programs generated from objective eSRT data.

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Julie Kosaner is an employee of MED-EL Hearing Implant Company

Objective To demonstrate the reliability of electrically elicited stapedius reflex threshold measures (eSRT) and the appropriateness of audio processor programs generated from these thresholds (THR).

Background
Objective fitting methods are preferred especially when the CI user is unable to provide unambiguous feedback. Maximun comfort level (MCL) can be set on each electrode at eSRT level and THR at 10% of MCL.eSRT to live voice can be used to check loudness of generated program.The adequacy of the provided program to access the user to quiet conversational sppech can be checked using aided cortical assessment (ACA).
Methods
10 children implanted<36months with a MED-EL CI were provided with a first audio processor program based on eSRT data.Each child was then immediately re-fit by a second audiologist blinded to the first audiologist's findings.MCL's set by each audiologist were compared.Each child underwent ACA within one week of first fit and after 1,2 and 3 months of CI use.Responses to speech tokens /M/,/G/,/T/ presented at 55 dBSPL were evaluated using the Fonix HearLab system by Frye.Presence of P1 and P1 latencies were analyzed at each test interval.

Results
No significant differences were found in MCL's set by different audiologists.CI users had P! responses to all speech tokens with latencies within the reference range within 3 months of switch on.

Conclusion
eSRT's are reliable and repeatable.Audio processor programs based on eSRT data adequately access users to sound and allow for auditory maturation.

P51

An objective procedure to set bilateral cochlear implant stimulation levels in children: A balancing act

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No conflicts of interest to report.

Objectives
Design and use a novel objective method to determine bilaterally balanced cochlear implant (CI) levels in children.

Background

Children with bilateral CI rely primarily upon interaural differences in stimulation levels for sound localization. A method to program bilaterally balanced levels along the CI arrays for sound coming from the front is thus needed. As we previously showed, this cannot be done by matching loudness levels in each device and rather requires listening to bilateral input.

Methods
Ten children who were bilaterally implanted were recruited as participants for testing. Synchronized trains of 1000 biphasic electrical pulses delivered at 900MHz with a pulse width of 25μs were presented to both CIs (Electrodes 5, 10, and 18). Balanced levels were obtained by asking children to identify which side of their heads they heard the sound, and using an automated bracketing algorithm based on their responses to find a range of levels to which they were uncertain.

Results
A range of uncertainty/balance was established in all participants. Some children had wide spans of bilateral levels to which they were uncertain while this range was narrower in others. The range was essentially consistent across the tested electrodes relative to each individual.

Conclusions
A new objective measure was used to define and characterize balanced bilateral input levels in children with CI. This tool should be considered for future CI programming software and design.

P52

Using Schroeder-phase Harmonic Complexes to Develop an Objective Measure of Temporal Processing in Cochlear Implant Listeners

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Objectives
This study investigates the use of Schroeder-phase harmonic complexes to develop a cortical evoked potential (CEP) based objective measure of temporal processing in cochlear implant (CI) users.

Background
Recent work from our group has shown that CEPs can be used to obtain a robust objective measure of spectral resolution in CI users (Lopez Valdes et al., PLoS ONE 2014). Since speech perception is dependent on both spectral and temporal processing abilities, this work could be complimented by developing an objective measure of temporal processing. Drennan et al. (JARO 2008) have shown that Schroeder-phase harmonic complexes can be used in a psychoacoustic paradigm to assess temporal processing in CI users. This study explores the feasibility of using these stimuli to objectively assess temporal processing.

Methods
Psychoacoustic discrimination of positive and negative Schroeder-phase complexes were measured using a four-interval two-alternative forced choice (2AFC) paradigm, using stimuli with fundamental frequencies of 10, 50, 100 and 200 Hz. Neural discrimination thresholds were obtained by recording single-channel EEG from subjects listening to Schroeder-phase complexes of the same fundamental frequencies using an oddball paradigm. Thresholds for psychoacoustic and neural discrimination were analysed for correlation.

Results
Using Schroeder-phase harmonic complexes we were able to obtain CEPs from all four cochlear implant subjects recorded to date. Current focus is on recruiting more subjects and correlating subject's CEP responses with their psychoacoustic discrimination abilities.

Conclusions
Schroeder-phase harmonic complexes may provide clinically useful stimuli for the development of an objective measure of temporal processing in cochlear implant users.

P53

Relationship of the electrical auditory brainstem response threshold to the postoperative psychoacoustic levels in adults

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There is no financial or comercial conflicts to be disclosed.

Objective
To identify the relation between the electrical auditory brainstem response (eABR) threshold and the postoperative psychoacoustic levels in adults.

Methods
Among 47 patients implanted with the Digisonic SP between 2011 and 2013, and whose intraoperative eABR was assessed, we selected all the adults with post lingual deafness
with regular follow up in the cochlear implant group. Twenty patients fulfilled the criteria. EABR was assessed in three electrodes representing the apical, medial and basal region of the cochlea. The Bio-Logic Navigator PRO was used to record the potentials and the coil attached to the Digistim box and to the computer with Digistim software was used as stimulus generator, with a trigger cable connecting the two devices. Wilcoxon test was used with 5% level of significance.

Results
Intraoperative eABR threshold could be registered in 16 patients (80%), in at least one electrode and electrical artifact prevented the analysis of the waves in 4 patients (20%). Wave V was the most consistent with higher amplitude, seen in 80% of the patients with recordable responses, followed by wave III (60%) and wave IV (50%). Latencies (in μs) were, on average: 1,81±0,28; III: 2,55±0,40; IV: 3,13±0,23; V: 3,71±0,28. In half of the sample eABR thresholds were determined. It could be seen that the threshold is equivalent to the minimum audible stimulation level (T level) after three months of activation (p=0,04), but not to the comfort level (p=0,50).

Conclusion
Our results show that the eABR can be used to guide the determination of the minimum stimulation level in the fitting process.**Objective:** to identify the relation between the electrical auditory brainstem response (eABR) threshold and the postoperative psychoacoustic levels in adults.

P54

Loudness Perception at Neural Response Telemetry (NRT™) Threshold Levels for Different Pulse Widths

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There are no real or apparent conflict(s) of interest.

Objectives
To compare loudness levels at extrapolated NRT threshold levels (T-NRT) for a range of pulse widths (PWs).

Background
T-NRT profiles are widely used to facilitate fitting of cochlear implant users. We previously showed that an increase in PW facilitates T-NRT profile measurement in patients complaining about loudness with default PWs of 25µs. T-NRT profiles shift downward in current level (CL) with PW while overall T-NRT profile remained. This study compares loudness of the NRT measurement sequences at T-NRT CLs for a range of PWs.

Methods
15 adults implanted with a Nucleus® CI24RE(CA) were recruited to participate in this study. T-NRT CLs were identified for PWs of 25µs, 50µs, 75µs and 100µs on electrode 18 by extrapolating NRT Amplitude Growth Functions. Loudness at different PWs was compared using two-alternatives forced choice procedure. Loudness of NRT sequences at T-NRT level for 50µs PW was matched to NRT sequences using 25µs PW by reducing CL of the 25µs pulse.

Results
Loudness of NRT measurement sequences increased with decreasing PWs. Loudness matching of NRT sequences with PW of 25µs with NRT sequences with PW of 50µs showed that CLs of the 25µs pulse can be lowered with ± 10 CLs to reach equal loudness.

Conclusions
T-NRT can be measured at lower loudness levels with longer PWs allowing for a more effective and more patient friendly NRT profile measurement. Introduction of longer PWs in the automated T-NRT profile measurement (AutoNRT™) will be of potential benefit to the Nucleus implant users and needs further investigation.

P55

Vocal-tract length discrimination and spectral resolution in cochlear implants

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There is no conflict of interest.

Objectives
The primary objective is to characterize speaker discrimination abilities in cochlear implants (CI) along two principal, anatomically related voice dimensions: fundamental frequency (F0) and vocal-tract length (VTL). In CIs, F0 perception mostly depends on temporal resolution, while VTL perception depends on spectral resolution.

Background
Listeners use vocal characteristics to recognize and discriminate speakers, which is particularly important for speech intelligibility in crowded environments. F0 and VTL have been identified as the two main perceptual dimensions normal-hearing (NH) listeners rely on. Previous work on voice gender categorization in CI users has shown that while they are able to use F0 differences, they seem unable to exploit VTL differences.

Methods
VTL and F0 of natural speech segments were manipulated using STRAIGHT, in order to measure just-noticeable differences along these dimensions in CI users, using an adaptive 3AFC method. The results were compared to those of NH listeners tested with acoustic simulations of CIs.

Results
Similar to NH listeners, and as was previously reported in literature, F0 sensitivity in CI users was largely sufficient to discriminate male F0 from female F0. However, CI listeners were observed not to perceive VTL differences typically found between male and female speakers.

Conclusions
With current stimulation strategies, CI users are unlikely to be able to benefit from VTL differences between male and female speakers in concurrent speech situations, like NH listeners do. The VTL discrimination reflects functional spectral resolution for speech stimuli in the implant, and could therefore be used in clinical settings for fitting purposes.

P56

Intraoperative measurements using CR120 remote assistant

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Objectives
CR120 remote assistant is a new equipment to measure intraoperative electrode impedance and neural response telemetry (NRT) thresholds. The goal of this study was to compare the test results measured by the CR120 remote assistant and the data measured by the conventional clinical system.

Material and methods
Our investigations were performed in 25 patients with Nucleus Freedom and CI422 cochlear implants. We measured the intraoperative electrode impedances in CG and MP1+2 stimulation modes and the intraoperative NRT threshold levels using both the wireless handheld device and the standard clinical system. We compared the impedances and T-NRT values using the two different test devices.

Results
Our results showed NRT thresholds measured by the two different systems were similar. There was no significant difference and the correlation was very high. In addition, similar impedances were found in

those electrodes which did not work properly before. However, in those electrodes which were used before in order to identify NRT thresholds, the impedance values measured by the two different devices showed significant differences.

Conclusions
We can conclude that the CR120 remote assistant is reliable device providing help to measure electrode impedance and NRT threshold values intraoperatively. It is a simple, practical option to replace the conventional intraoperative measuring system in the operating theaters.

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P57

Characterization of Temporal Interactions in the Auditory Nerve of Adult and Pediatric Cochlear Implant Users

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No conflicts.

The realization of benefits of high pulse rates in CI users may vary with other pulse rate-dependent temporal interactions that occur at the neural membrane, e.g., per(i)stimulatory adaptation and its post-stimulatory or forward masking effects. This study attempted to characterize adaptation and recovery of the electrically evoked compound action potential (ECAP) in individuals with cochlear implants, both adults and children. We used constant amplitude pulse trains (100 ms in duration). The ECAP amplitude typically decreased over time and achieved a steady state within 100 ms. The ECAP amplitude at steady state was, on average, a similar proportion (50-70%) of the amplitude at onset for various stimulus levels and in both adults and children but long-term adaptation effects, evidenced by the decrease in onset ECAP amplitude, were greater in adults particularly at lower levels in the ECAP dynamic range. The forward masking effects of pulse train stimulation were quantified by the ECAP amplitude in response to a subsequent probe pulse normalized by the response to the same pulse presented alone. ECAP recovery of a probe preceded by a masker pulse train of equal level followed a monotonic or non-monotonic pattern consistent with a hypothesis of both adaptation and facilitation occurring with pulse train stimulation. We hypothesize that the variations in the recovery patterns may be attributable to individual differences in the status of the auditory nerve and possibly, the variations in temporal interactions across the spatial domain at different stimulus levels.

P58

Fitting Cochlear Implants in young children using the AUTONRT and the Stapedius reflex

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No conflict to disclose

Objectives
To correlate the comfort levels (C-Levels) evaluated during cochlear implant fitting with The AUTONRT Thresholds (T-AUTONRT) and Stapedius Reflex Threshold in a pediatric and adult population.

Background
Subjective C-Levels are one of the most important parameters of cochlear implant fitting. However most of studies disagree on the correlation between CL and objective measures. We investigated if this

disagreement could be different between early implanted pediatric and adult populations.

Methods
T-AUTONRTs were assessed in 40 patients (adults and children) implanted for more than one year with NUCLEUS FREEDOM and CI 512 , intra-operatively and postoperatively at 1 month, 6 month and one year after the activation. Stapedius reflex threshold was assessed postoperatively in a “Live-mode” using an impedance meter, with the probe placed in the contra-lateral side from the implanted ear.

Results
The difference between C-Levels and T-AUTONRT is not the same along the electrode array and is different from the adult and children populations. T-AUTONRT is very close to the C-Levels in the medial part of the electrode array in the children population. The T-AUTONRT level tends to decrease in the first month after set up.

Conclusions
It is possible to approximate the C-Levels in children with The T-AUTONRT under control of stapedius reflex for all the electrodes. Measures must be repeated regularly during the first six months after implantation because of the adaptation and then each year at the fitting session.

P59

AutoNRT™:Evaluating test-retest measurement reliability

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No real or apparent conflict(s) of interest

Background
The Nucleus Cochlear Implant (CI) system has the ability to measure the Evoked Compound Action Potential (ECAP) resulting from electrical stimulation of the spiral ganglion neurons.. The Nucleus CI system also has an automated system to determine this threshold level, known as AutoNRT™ . The accuracy of measurements including test-retest measurement reliability has been partially reported but further investigation is warranted. In addition, there is an incomplete understanding of whether aetiology or electrode type affects this measurement reliability. This investigation therefore aims to establish the test-retest measurement reliability of the ECAP threshold and whether the reliability is correlated to demographic or device factors.

Objectives
The primary objective of this investigation is to establish the test-retest measurement reliability of Evoked Compound Action Potential (ECAP) thresholds using the AutoNRT™ system.
The secondary objective of this investigation is to determine whether test-retest measurement reliability of ECAP thresholds is correlated to either aetiology, surgical issues or electrode type.

Method
36 patients who have previously received a Nucleus CI24RE,CI422 or CI512 cochlear implant for treatment of severe to profound hearing loss were included in the study. All subjects are unilateral CI users.The age range of the patients is 13 months to 46 years.

The Evoked Compound Action Potential (ECAP) thresholds are measured on all operational electrodes twice, with 10 minutes between measurements.

Results
Auto NRT thresholds obtained in two consecutive sessions were compared.Results of this study have found a great variability of NRT measures within and across patients.

AutoNRT test rest reliability was found to be high when all testable electrodes were compared but when the results were compared on electrode basis, the reliability was not high on every electrode.The results will be discussed in the light of subjects' demographics and electrode type.

P60

Measures of Electrical Field Interactions by Recording of EABR in Cochlear Implanted Patients

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Objectives
To design a simple and specific test to evaluate the magnitude of channel interactions using EABR (evoked auditory brainstem responses).

Background
Variability of performance among cochlear implant (CI) patients could be related to the electrical interactions which limit the number of effective and an independent stimulation channels. The EABR reflects both the nerve activity and responses from ascending nuclei in the lower brainstem and then may be sensitive to i) spiral ganglion loss and electrode-to-neuron distance (cochlear level), ii) channels interactions during the first central neural processing, which is critical for auditory processing.

Methods
Data were collected for 2 adult CI recipients (Digisonic SP – Neurelec®). Patients were chosen regarding their audiometric testing with one with a good result (>70% with percentage correct scores of Vowel-Consonant-Vowel (VCV) test) and the other one with a bad results (< 30%). We intended to measure interactions on the electrode number (EN) 12 provoked by E11 and E13. Several measures of EABR were done with a simultaneous stimulation of the three electrodes: Interaction electrode (EN 11 and EN 13) were always stimulated at 70% of the dynamic range, and at each measure, the probe electrode (EN 12) was stimulated according to various stimulation levels.

Results
Fewer interactions (analyzed by means of the refractory period) were found on patient with a good audiometric result.

Conclusions
The results of this study suggest that there is a relationship between electrical-field interactions measured by EABR and speech recognition performance. Further confirmations will require more data.

P61

An objective measurement of loudness growth in bimodal listeners

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Loudness growth functions (LGF) are currently not used for fitting auditory prostheses because behavioural measurements are time-consuming, complicated and require active cooperation of the patient. In bimodal listeners, this leads to distorted interaural loudness relations as the LGFs of the cochlear implant (CI) and the hearing aid's compression system are different. This study aims to develop

an objective method of measuring loudness growth in bimodal listeners to fit the devices accordingly. Comparisons between LGFs and objective measurements are already described in literature. While no clear relationships with auditory brainstem responses or otoacoustic emissions were found, a correlation between the auditory steady-state response (ASSR) amplitude and the LGF was found in normal-hearing subjects, although an imprecise loudness scaling method was used and loudness adaptation effects were not taken into account.

In this study, loudness and ASSR growth in normal-hearing subjects, unilateral CI listeners and bimodal listeners are measured. Acoustic stimulation consists of unmodulated and 40Hz amplitude-modulated sinusoids (0.5 and 2kHz). For electric stimulation, unmodulated and 40Hz amplitude-modulated 900pps pulse trains are used. For measuring loudness growth, subjects have to rate the loudness of short-duration stimuli by absolute magnitude estimation (AME) and on a graphical rating scale. A successive AME task is used to investigate loudness adaptation effects in long-duration stimuli which are used for ASSR measurements.

We will present conclusions on the extent to which ASSR growth is correlated to the LGF in normal-hearing, CI and bimodal subjects, and on whether loudness adaptation effects need to be considered when measuring ASSRs.

P62

Improved threshold detection in electrically evoked auditory steady state responses for the objective fitting of cochlear implants

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Currently, cochlear implant (CI) fitting in infants is challenging, as infants are not able to give conscious feedback on the perceived loudness of the stimuli. Electrically evoked auditory steady state responses (EASSRs) are investigated for objective CI fitting, because electrophysiological thresholds obtained with EASSRs correlate well with behavioral thresholds in bipolar mode (Hofmann and Wouters, 2012).

In this study, evoked EEG potentials in response to monopolar pulse trains at different intensities were measured in 6 subjects, by means of a 64-channel recording system. The pulse trains were amplitude-modulated with a fixed modulation depth and had a pulse rate equal to the subject's clinical rate (i.e. 900 pps). T-levels were measured for modulated pulse trains and unmodulated and modulated pulse trains were loudness balanced at the subject's C-level, to compensate for the difference in perceived loudness between both. To remove stimulation artifacts and retrieve the the underlying neural responses, a combination of the established blanking method with a new CI artifact rejection technique based on Independent Component Analysis (ICA) was used.

The results show that the proposed artifact rejection method reduces false response detections due to the stimulation artifacts and that EASSRs can be detected at stimulus intensities as low as 22% of the subject's dynamic range. For supra-threshold responses, artifact-free determination of response properties allows the determination of response growth functions for monopolar pulse trains at clinical rates. Quantitative measures illustrating the advantages of ICA based artifact rejection and the results of the behavioral loudness balancing will be presented.

P63

Cortical measurements via the cochlear implant sound processor

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Objectives
To investigate the feasibility of measuring cortical responses via the cochlear implant sound processor with stimuli and trigger produced by a general purpose laptop computer.

Background
It is sometimes desirable to apply cortical measurements to objectively evaluate a cochlear implant recipient's ability to discriminate acoustic stimuli. When doing so, it makes sense to include the sound processor. This is most logical if the test stimuli are specific to the recipient's cochlear implant channel allocation and requires more flexibility than is typically available in an EP machine.

Methods
Using Matlab, stimuli were created that were matched to the centre frequencies of the Advanced Bionics HiRes and Fidelity 120 filterbanks. These stimuli were arranged as one channel of an audio file. The second channel was composed of a monophasic "pulse" synchronized in time to the audio track. The stereo audio tracks were saved as a .wav file and played from a standard laptop computer. The audio channel was delivered to the auxiliary input of the Harmony sound processor using the 20 dB attenuated input setting. The pulse was fed through a battery powered level shifter that produced a 5 volt trigger signal for the EP machine. Playing the audio file delivered stimulation patterns to the implant and synchronized the EP machine.

Results
The synchronization method works and data have been recorded from a test subject. Discrimination of adjacent channels has been demonstrated objectively. Further subjects are being recruited for testing with those unable to discriminate adjacent channels being sought. Data from a group of five subjects will be presented.

Conclusions
The flexibility to easily tailor test stimuli to match the characteristics of an individual's cochlear implant programme has been demonstrated. Evaluating cochlear implant recipients with the sound processor they use to listen through may provide more insight into listening abilities. This could support programming decisions, including switching off non-discriminable electrode contacts.

P64

Early activation in Cochlea Implantation - A retrospective study

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Conflict of interest: none

Background
Cochlear implantation is a clinical routinely treatment for patients with severe sensorineural hearing loss

for over 20 years. Up to now, the general recommendation for speech processor activation was four weeks after cochlear implantation. The aim of this study was to determine whether activation is possible at less than four weeks postop and to show the postoperative change in telemetry over time.

Methods
The study was retrospectively carried out at the Landesklinikum St.Pölten, Austria.
Patients who routinely received a CI between January and August 2013 were included in this study. 2 weeks after the surgery clinical complications, the ability to wear the audio processor and the impedance values were analyzed.

Results
45 patients were included in this study. 40 patients were examined at the first postoperative visit, scheduled two weeks after the surgery. In nine cases a mild wound healing complication occurred; just in one patient the activation could not carried out immediately. There were no statistically significant differences between the intraoperative, the two- and six-week postop impedance measurements for each channel.

Discussion
We used the minimally invasive approach and soft implantation technique in all of our patients, and believe this to have been a major reason that earlier activation was possible. With this technique, you can reduce the wound healing process, which makes it possible for the wound to heal fully and for the patient to wear the sound processor over the wound without problems. We found out, that telemetry is not a predictor for the time of activation.

Conclusions
Based on the results in this study an earlier activation can be recommended. This will shorten the time the patient needs to wait following cochlear implantation, and rehabilitation can begin sooner.

P65

Pupillometry and hearing level in cohlear-implanted children

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Identify any real or apparent conflict(s) of interest. None

Objectives
To develop an objective measure of auditory comfort threshold in adult patients with cochlear implant by measuring their pupil size during a listening task.

Background
There is currently no objective measure of hearing level we could use during cochlear implant fittings in young children at pre lingual stage, which makes difficult the assessment of comfort level in this population. According to the literature, the variation of pupil size is related to the complexity of mental processing and can be considered as the reflection of cognitive load. The aim of this preliminary study is to develop an objective measure of auditory comfort threshold in adult patients with cochlear implant by measuring their pupil size during a listening task.

Methods

Thirteen post lingual cochlear-implanted adults (mean age 48 y.o. +/-17,7) were included. The mean experience with cochlear implant was 6 years (+/- 5,7). The sex ratio was 1,5F/1M. The main etiology of deafness was progressive hearing loss. Patients were exposed to 4 lists of 10 spoken french words available in 4 different intensities (30, 50, 70, 90 dB SPL). A silence period of 5 seconds was placed between each list. No order was given to the participants. Pupillometry data were recorded every 17 ms using an eye-tracking system in a quiet room. Data were compared to a control group of 32 normal hearing adults (25 y.o. +/- 4,1) who passed an audiometry test. We investigated the latency and amplitude of dilation and constriction, the pupil mean size variation, maximal reactivity, and the relative peak of dilation which corresponds to the ratio between maximum peak dilation divided by the pupil-size dynamic range between dilation and constriction. All the data were compared to the baseline, which is the mean value of pupil size within the last second before stimulation.

Results
Mean pupil size was larger at high intensity (90 dB SPL) compared to low intensity (30 dB SPL) in both groups. The relative peak of dilation was higher when exposed to high intensity (90 dB SPL) than low intensity (30 dB) in both groups. The amplitude of dilation was significantly larger at 90 dB than 30 dB in the control group. No significant difference was observed concerning the dilation latency and the constriction latency in both groups.

Conclusions
Pupil dilates with cognitive load and high intensity. The measure of pupil size during a listening task such as exposure to different intensities could be a new method to assess the patient's discomfort threshold, especially in young children in order to identify pupil's largest value during the implant fittings.

P66

Beyond speech intelligibility testing: A memory test for assessment of signal processing interventions in ecologically valid listening situations

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Performance of hearing aid signal processing is often assessed by speech intelligibility in noise tests, such as the HINT, CRM, or SPIN sentences presented in a background of noise or babble. Usually these tests are most sensitive at a signal-to-noise ratio (SNR) below 0 dB. However, in a recent study by Smeds et al. (2012) it was shown that the SNRs in ecological listening situations (e.g. kitchen, babble, and car) were typically well above 0 dB SNR. That is, SNRs where the speech intelligibility in noise tests are insensitive.
Cognitive Spare Capacity (CSC) refers to the residual capacity after successful speech perception. In a recent study by Ng et al. (2010), we defined the residual capacity to be number of words recalled after successful listening to a number of HINT sentences, inspired by Sarampalis et al. (2009).
In two recent tests with 26 and 25 hearing impaired test subjects, respectively, we showed that close to 100% correct speech intelligibility in a four talker babble noise required around + 7-9 dB SNR. At that SNR it was shown that a hearing aid noise reduction scheme improved memory recall by about 10-15%. Thus, this kind of memory recall test is a possible candidate for assessment of hearing aid functionality in ecologically relevant (positive) SNRs.

P67

Transformation of lost segregation cues in hearing devices

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Can transformation of lost TFS cues help hearing impaired listeners in situations that require 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 out on the TFS information, as the stimulation strategies discarded all TFS. Taken together the role of TFS is interesting for all kinds of hearing losses and hearing devices.

In particular, the TFS1 listening test developed by Moore and Sek (2009) is very difficult for mild-to-moderate hearing-impaired listeners. 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 TFS2ENV transformation enables the hearing impaired listeners to perform the TFS1 test with similar performance as normal hearing listeners.

The present study will also compare the results of the listening test with cortical measures with and without the TFS2ENV. This will reveal if the TFS2ENV is capable of restoring both amplitude and timing in the cortical responses that are similar to normal hearing listeners.

While TFS2ENV provides benefits for the discrimination tasks in the TFS1 test, it remains to investigate if the benefit also carries over to segregation of voices. For cochlear implants it also remains to investigate if TFS2ENV provide supplementary benefits together with stimulation strategies that convey TFS.

P68

Key Contributors to Successful Bimodal Fitting

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Identify any real or apparent conflict(s) of interest: This work was supported in part by a research grant from Advanced Bionics.

Objectives
To qualitatively and quantitatively assess the daily-life experiences of CI-patients who do or do not wear a contralateral hearing aid.

Background
An increasing number of cochlear implant (CI) patients has enough residual hearing in the non-implanted ear, to benefit from a conventional hearing aid (HA). The goal of this study was to investigate the self-reported experiences of unilateral CI-patients who do or do not use a contralateral HA in daily life, and to relate bimodal benefit to psycho-physical measures.

Methods
A retrospective cohort study among adult unilateral CI-patients was carried out using questionnaires. Furthermore, a psycho-physical test battery was validated and administered to a subset of bimodal users. Correlations were investigated between bimodal benefit (e.g. speech-in-noise and listening effort) and influencing factors (e.g. device fitting, spectral- and temporal resolution and overlap, loudness balance and cognitive skills).

Results
Comparisons between unilateral and bimodal listeners show no difference in self-rated disability between the two groups. However, within the group of bimodal listeners, bimodal benefit is consistently observed, both subjectively (questionnaires) and objectively (speech-in-noise performance, listening effort). Concerning psycho-physical measures, loudness as a function of input level appears to be the most promising contributor to bimodal benefit, along with spectral and temporal acuity. A follow-up project will focus on constructing an efficient and clinically applicable bimodal fitting procedure.

Conclusions
Bimodal users consistently experience bimodal benefit across daily life listening situations. Loudness growth function appears to be the most promising contributor to bimodal benefit.

P69

Progressively recovering auditory brainstem response in a cochlear-implanted child after meningitis

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Objectives
We describe the case of an 8-year old boy who developed meningitis five years after implantation and how EABR is used in the assessment of his hearing performance after recovery.

Background
An 8-year old boy stopped using both his cochlear implants due to streptococcal meningitis accompanied with purulent otitis media on the left ear. After recovery his hearing was quickly restored on the right ear but he complained of not hearing well on the left ear. EABR was used in an attempt to elucidate the discrepancy between ears.

Methods
EABRs were measured on both ears two months after meningitis offset. Testing was repeated on the left ear 12 and 18 months after the first session. Responses were evoked by apical, mid-array, and basal electrodes. When possible the patient was asked to tell whether or not the stimulus was heard at different levels.

Results
At initial testing EABRs were normal on the right ear. They were absent on the left ear for the apical electrode and present but with delayed wave latencies for the middle and basal electrodes. At the second and third sessions EABRs were present for all electrodes and wave eV latencies were shorter. The stimulus level needed to evoke an EABR was considerably reduced on all electrodes from the first to the third session. There was good agreement between these findings and the subjective feedback from the patient.

Conclusions
EABR provided valuable information throughout the patient's hearing recovery. Its use should be considered in difficult patients, especially those who cannot give feedback.

P70

Electrophysiological correlates of listening effort on speech understanding in cochlear implant users

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This work was supported by the DFG Cluster of Excellence EXC 1077/1 "Hearing4all". The company MED-EL paid financial reimbursement for the participants of the study and paid the travel expenses of MF.

Objectives
The aim of the present study is to investigate how cognitive/linguistic competence relates to speech understanding in cochlear implant (CI) users. Importantly, electroencephalography (EEG) can provide insights to the neuronal processing of stimuli. The event-related potential (ERP) P3 peaks around 300 ms after stimulus presentation. It represents a higher level of neural processing and can be related to the time a person needs to classify stimuli. Additionally, early ERPs (N1-P2 complex) can give insights on the automatic processing of the stimuli.

Background
The P3 component has been related to listening effort in normal hearing persons as well as in CI users. Moreover, working memory capacity (WMC) and linguistic competence could explain differences in listening effort and CI performance in previous studies. The present study combines both aspects.

Methods
WMC and linguistic competence is assessed in CI users. Consecutively, they listen to speech stimuli in quiet and noise while having their EEG recorded. We use an active oddball paradigm: Participants are asked to press a certain button every time they hear rare target stimuli intermixed in frequent standard stimuli.

Results
We will report effects of noise and WMC/linguistic competence on ERP amplitudes and latencies for cochlear CI users and relate them to their speech tests.

Conclusions
This paradigm offers an objective measure of speech understanding in different listening conditions and the related listening effort (in dependence on linguistic competence and WMC).

P71

A longitudinal assessment of spectral ripple discrimination and speech perception in new cochlear implant users

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Objectives
Longitudinally track of newly implanted CI users to determine the relative time course of the development of neural and psychophysical spectral discrimination abilities, and speech perception.

Background
Won et al. (JARO 2007) suggests that CI user's ability to discriminate spectrally rippled noise stimuli is correlated with their speech perception. Previously (Lopez Valdes et al, PLoS ONE 2014) we showed a correlation between behavioral and neural spectral ripple discrimination, measured using cortical evoked potentials (CEP) and an oddball paradigm. We aim to study these metrics longitudinally.

Methods
Behavioural and neural spectral ripple discrimination thresholds as well as speech perception scores were measured in five subjects over a six month period. Four measurement sessions were conducted: switch-on date, one week, three weeks and six months after switch-on. Behavioural spectral ripple discrimination was measured using a three-alternative forced-choice threshold tracking paradigm (Won et al., JARO 2007). Neural spectral ripple discrimination was measured in response to spectrally rippled broadband noise at 0.25, 0.5, 1 and 2 ripples per octave (Lopez Valdes et al., PloS ONE 2014). Speech perception scores were obtained via BKB sentences and AzBio sentences, in quiet and in noise, presented monaurally directly to each subject's speech processor.

Results
Three patients tested to date by the third week show an increase in behavioral spectral discrimination abilities and changes in morphology of CEP, while speech perceptions scores remain unchanged.

Conclusions
Longitudinal assessment of spectral ripple discrimination and speech perception may potentially provide additional insights to plasticity and performance outcomes in CI users.

P72

The binaural interaction component: a method to monitor plasticity in bimodal listeners?

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Objectives
To investigate plasticity in the binaural auditory system in bimodal listeners.

Background
Bimodal hearing refers to the condition in which electric hearing via a cochlear implant (CI) is combined with residual hearing in the non-implanted ear. Psychoacoustic research suggests that bimodal listeners can benefit from binaural integration. There is, however, an unexplained variability in bimodal outcome. It is hypothesized that at least some of this variability can be explained by plasticity. It is expected that binaural interaction develops with increasing bimodal experience. Furthermore, subjects who wore bilateral hearing aids may be more likely to binaurally integrate electric and acoustic signals. We believe that the binaural interaction component derived from the auditory brainstem response (ABR-BIC) can be a useful technique to measure plastic changes during the first months of bimodal hearing.

Methods
ABR-BICs are computed by subtracting the binaural response from the sum of the left and right monaural responses. A protocol that combines acoustic and electric stimulation is set up to obtain ABR-BICs in bimodal listeners. In a first study, ABR-BICs are measured by accounting for the latency differences between the acoustic and the electric wave V. In a second study, ABR-BICs are measured without accounting for this.

Results
Both protocols will be presented, as well as the results of a pilot study. Preliminary data of the first study suggests that binaural interaction can occur in bimodal listeners.

Conclusions
A better understanding of the mechanisms of inter-subject variability in binaural interaction can lead to better and more adequate counseling.

P73

ECAP Latency Regarding Masker-Probe Stimuli

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Objectives
ECAP recordings provide information on the condition of nerve fibres which can be used for monitoring of neural health.

Background
In a multi-centre study [www.hearring.com; “Auditory Nerve Response Telemetry (ART) Study of the Hearring Group”] the electrically evoked compound action potentials (ECAP) of 141 subjects implanted with MED-EL standard and FLEXsoft electrode arrays were investigated. ECAP amplitudes, latencies and double peak presences were manually determined by experts.

Methods

ECAP signals elicited by three different stimulation electrodes (regions apical / middle / basal) using single biphasic pulses (Amplitude Growth Functions, AGF) and two consecutive biphasic pulses (Masker-Probe within Recovery Functions, RF) are regarded.

Results
A latency shift in ECAP-signals following a single biphasic pulse was already discussed with respect to the presence of double peak signals [Proceedings of Objective Measures 2012: K. Schwarz, “ECAP Latency as Function of Distance between Stimulation and Recording Electrode”].
For ECAP signals following two consecutive pulses, a remarkable prolongation of the latency up to 0.1 ms for short inter-pulse-intervals (IPI) is present for all three stimulation regions. For apical and middle stimulation, a statistically significant difference in latencies is visible if the recording electrode is varied from apical to basal neighbours.
For single peak signals, a constant duration of ECAP signals for different IPIs (latency difference positive-negative peak is about 0.4 ms) is present. For double peak signals, the ratio of the ECAP-amplitudes concerning the two positive peaks ”later peak / earlier peak” increases for small IPIs.
The arising question whether the latency shift for small IPIs is related only to the answer of the first pulse or if there is a physiological reason is examined.

Conclusions
A possible physiological reason (“Fibres resulting in early ECAP-signals have longer refractory periods”) is assured by the constant signal duration and the amplitude ratio of double peak signals..

P74

Delayed auditory brainstem responses in prelingually deaf and late implanted cochlear implant users

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Objectives
To compare electrically evoked auditory brainstem responses (eABRs) and its wave latencies between pre- and postlingually deaf, late-implanted cochlear implant users.

Background
eABRs have been suggested as a biomarker for the development of the auditory brainstem. Insufficient auditory stimulation during childhood might therefore lead to an impaired neural conduction and consequently prolonged eABR wave latencies.

Methods
eABRs were obtained in 23 late implanted, adult cochlear implant users who were either pre- or postlingually deafened. The eABR wave III and V latencies were compared between the pre- and postlingually deafened group.

Results
In 87% of all subjects eABR waveforms could be evoked on an apical electrode. The average latency of wave V in the prelingual group (3.85 ms) was significantly longer than in the postlingual group (3.61 ms). Wave III was around 2 ms and did not significantly differ between both groups. Consequently, the wave III-V interval was significantly longer in the prelingual group as compared to the postlingual group. Latencies were not related to the duration of implant use.

Conclusions
eABR wave V latencies are prolonged in prelingually deaf and late implanted adult CI users as compared to CI users who had sufficient auditory stimulation during childhood and adolescence. These prolonged latencies in the prelingual group might represent abnormal neural conduction in the brainstem pathway, due to the long period of auditory deprivation and impaired development.

P75

Poster Withdrawn

P76

Simultaneous Recording of ECAPs and EABRs using the Advanced Bionics RspOMTM and the Echodia EliosTM system

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Objectives

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
Ten 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 recorded in 3 out 4 subjects included so far. No post-stimulus remaining artifact was observed. Each recording showed a clear wave III ranging from 2.3 to 2.6 ms and a smaller wave V. Wave I could be extracted and was compared to ECAP growth functions.

Conclusion
EABRs were successfully recorded in combination with ECAPs, relationship between these provide useful insight into auditory nerve activity, which may be relevant to assist in implant programming.

P77

Alpha Suppression in CI Patients with SSD Reflect Post-Implantation Increase in Healthy Ear Comprehension of Degraded Speech

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Nothing to disclose.

Objectives
The effects of cochlear implantation on healthy ear comprehension of degraded speech in patients with single-sided deafness (SSD) are examined using behavioral and electrophysiological measures.

Background
The suppression of auditory alpha oscillations during speech processing has been shown to be correlated with the level of comprehension of spectrally and temporally degraded words. Since cochlear implants (CIs) present the wearer with spectrally degraded speech while leaving the temporal envelope intact, it is expected that processing of spectral and temporal speech degradation will be affected by CI implantation.

Methods
In a cohort of 4 adult CI patients with late-onset SSD, words were presented to the healthy ear with varying degrees of spectral and temporal degradation via vocoding and envelope smoothing. This was done in two sessions – preoperatively and 3 months post-implantation. Neural responses were recorded using 128 channel EEG. Additionally, patients were asked to rate their level of comprehension for each word.

Results
Behavioral measures and greater alpha-suppression over a cluster of parietocentral electrodes reflect an increase in comprehension post-implantation for temporally degraded speech, but not spectrally degraded speech.

Conclusions
These initial improvements in comprehension of temporally degraded speech may represent an increased reliance on temporal envelope cues by the implanted ear. A resulting healthy ear benefit could indicate shared speech processing pathways with the implanted ear. Further work will determine if there is a correlation between implanted ear and healthy ear processing of degraded speech.

P78

Objective Evaluation of Bilateral Cochlear Implantation

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One of us (TH) is working for Cochlear Deutschland

Objectives
To describe a test setup for evaluation of bilateral cochlear implant processors and to present first data.

Background
During the last decade bilateral cochlear implantation became a standard therapy in bilateral deafness. In particular, speech perception in noise and directional hearing seem to improve by the second cochlear implant. The primary effect seems to be due to the bilateral summation and reduction of head shadow. Further effects of bilateral timing like the squelch effect are still under discussion. Usually, the left and right speech processor are working independently with its own processing timing.

Methods
Two cochlear implant speech processors were attached to non-implanted cochlear implants and placed at the typical position in a free field with a distance of about eighteen centimeters. Implant stimulation was recorded with a computer based measurement system for both processors simultaneously. Electrodograms for both electrode outputs were registered and prepared for comparison. Time delays were determined by correlation analysis.

Results
While interaural time delays in the range of less than microseconds were not observed in single frames they were detectable when analyzing longer trains of acoustic stimuli.

Conclusions
Hence, interaural time delays below 1 millisecond can be objectified on the level of the cochlear with typical speech processor settings even for non-synchronized speech processors.

P79

Cortical Refractoriness and the N1-P2 Evoked Potential in Cochlear Implant Listeners

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Background:
Measuring auditory evoked potentials (AEP) can be a useful objective tool which provides information on central auditory performance and allows objectifying cortical activities. Former studies already showed a significant influence of stimulus parameters as intensity, duration and interstimulus interval [1, 2].

Objectives
The main goal of this study was to measure the influence of the interstimulus interval (ISI) and the locality of the stimulus within the cochlear for cochlear implant (CI) users on cortical AEP.

Methods
The AEP-data was collected with the NEUROSCAN Synamp II at vertex in 25 experienced CI-users (nucleus freedom or CI512). Stimuli were built of 300 ms long pulse trains for three different electrodes. The C-level was adjusted to a comfortable loudness level for each electrode. Pauses in between the stimuli were set to 300 ms, 900 ms, 1400 ms, and 5000 ms. These CI-stimuli were presented using a research speech processor (L34 Cochlear Ltd.). The resulting AEPs were analyzed with regard to the P1-N1-P2 complex.

Results
Outcomes show a significant increase of the N1-P2 interpeak magnitude with increasing ISI for all three investigated electrodes. Potentials also increase significantly within the cochlear apical to basal - particularly for large ISI.

Conclusions

Auditory evoked potentials can be reliably measured in CI-users. Increasing the stimulus rate results in lower potential amplitudes, which is evidently due to refractory cortical neurons. The magnitude difference for apical and basal electrodes may be related to the hearing loss progress prior to implantation.

[1] Schönweiler, R., Wübbelt, P., Tolloczko, R., Rose, C., Ptok, M. (2000) Classification of passive auditory event-related potentials using discriminant analysis and self-organizing feature maps. Audiology and Neurotology; 5:69-82.
[2] Hari, R., Kaila, K., Katila, T., Tuomisto, T.,Varpula, T. (1982) Interstimulus interval dependence of the auditory vertex response and its magnetic counterpart: Implications for their neural generation. Electroencephalography and clinical Neurophysiology; 54:561-569.

P80

Evaluation of speech-evoked envelope following responses as an objective hearing aid outcome measure

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Objectives
The study aims to evaluate the use of a novel test paradigm based on speech-evoked envelope following responses (EFRs), as an objective hearing aid outcome measure. We investigated the effects of stimulus level, bandwidth, and amplification in adults with normal hearing (NH) and hearing impairment (HI).

Background
The proposed method uses a naturally spoken speech token, /susaʃi/. The token was modified such that eight individual EFRs can be elicited from a wide frequency range. Recording of two EFRs per vowel was enabled by changing the pitch in selected formant regions. Recording of EFRs evoked by the fricatives was enabled by amplitude modulating the fricative band.

Methods
To evaluate sensitivity to level and amplification, 20 NH adults were tested unaided (using an ER-2 receiver), and 21 HI adults were tested unaided and aided using a hearing aid at 50 and 65 dB SPL. To evaluate sensitivity to stimulus bandwidth, EFRs were also recorded in three low pass filtered conditions (1, 2 and 4 kHz) at 65 dB SPL.

Results
The number of EFR detections increased with level in NH, and with level and amplification in HI adults. The amplitude of most EFRs increased with amplification in HI adults. Both groups showed an increase in amplitude and the number of detected EFRs with wider stimulus bandwidths.

Conclusions
Findings suggest that the proposed test paradigm is sensitive to changes in stimulus level, bandwidth, and amplification in NH and HI adults, and hence may be useful as an objective hearing aid outcome measure.

P81

Improving Accuracy of Neural Source Localisation in Individuals with Cochlear Implants: Application for Measuring Brain Plasticity

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Objectives
To determine if source localisation measures can be refined for cochlear implant (CI) users based on a more accurate estimation of the head model.

Background
Brain plasticity underlies changes in auditory perception over time once a CI is activated. Objective measures such as electroencephalography (EEG) can be used to monitor plastic brain changes post-implantation by estimating location and strength of the underlying neural sources in response to stimuli. However, most studies have estimated neural sources using an averaged-head model to estimate scalp-electrode positions rather than using digitized-electrode positions, and did not use individual brain images to identify structures associated with the neural sources.

Methods
Three studies were conducted. The first investigated the extent to which digitization was influenced by magnetic interference from CIs. The second compared EEG neural-source estimates in response to pure tones (0.5, 1.0, 2.0 and 4.0kHz) using a standard-electrode model and using digitized-electrode positions, in normal-hearing listeners. The third study used similar stimuli to study two with CI users (who had pre-operative MRIs), and EEG was recorded with digitized-electrode positions.

Results
Results showed that CIs do not interfere with digitized 3-D coordinates from electrode digitization. There was a significant difference between both dipole location and strength when using the averaged-head model compared to digitized positions; suggesting improved accuracy with digitized-electrode positions. Results were used to verify the accuracy of neural-source localization using pre-operative MRIs combined with EEG and digitization.

Conclusion
More accurate estimates of underlying neural sources can be used for measuring brain plasticity post implantation.

P82

Does decreasing binaural integration resulting from asymmetry in brainstem function correspond with decreased binaural advantage in speech perception?

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Objectives
To determine if benefits of bilateral cochlear implant on speech perception in children can be predicted by asymmetric brainstem function.

Background
We have shown that children with long delays between implants have asymmetric speech perception which compromises improvements found with bilateral over unilateral cochlear implants. We have also

shown that input from bilateral implants becomes increasingly perceived as two separate sounds as asymmetry in brainstem function increases. Perhaps, this abnormal perception/increased brainstem asymmetry further exacerbates asymmetry in speech perception and reduces the advantage of bilateral implantation in children.

Methods
Speech perception was measured in 144 children using standard and age appropriate tests from 6 months after bilateral implantation and at regular intervals thereafter. Brainstem function was evoked on each side with biphasic electrical pulses delivered at 11 pulses/s from a basal and apical electrode and recorded at center mid-line of the head on the same day ± 3 months of speech perception testing.

Results
Asymmetry in brainstem latencies between the two sides were significantly longer in children who received bilateral cochlear implants sequentially rather than simultaneously ($p<0.05$). Bivariate correlation analyses between speech perception scores and brainstem latencies were not significant ($p>0.05$).

Conclusions
Increased asymmetry in brainstem response latencies occurs in children with sequential bilateral cochlear implants, consistent with previous data showing effects of unilateral use on brainstem development. These changes cannot predict the large variability in speech perception outcomes in children using bilateral cochlear implants.

P83

Cost Effectiveness and Equivalency of New Intraoperative Measuring Technology

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Objectives
To investigate the equivalency of the CR220 Intraoperative Remote Assistant to standard clinical equipment. To determine the cost effectiveness and the improvements possible when unproductive waiting is reduced or removed.

Background
The centre has previously investigated the first generation intraoperative remote assistant. This work has now been extended to the second generation CR220 Intraoperative Remote Assistant device. Additional focus has now been paid to how using a wireless handheld device can reduce unproductive time that would be otherwise spent travelling or waiting.

Methods
113 patients were implanted with a cochlear implant through normal treatment for hearing loss. Intraoperative ECAP thresholds were measured using both the standard clinical equipment and the CR220 Intraoperative Remote Assistant. The ECAP thresholds were compared for statistical equivalency. A specially developed “intraoperative session survey” was developed which recorded the time taken for every stage of the measurement activity. These durations were collected for each surgery.

Results
The ECAP thresholds measured with the two systems were to be significantly equivalent to with 2 current levels. The travel/waiting time was two or more hours per surgery. A full overview of the task time

information will be presented, with an estimate of cost effectiveness for a non-expert audiologist to conduct the measurement activity.

Conclusions
The ECAP thresholds measured with the CR220 Intraoperative Remote Assistant were found to be equivalent to those measured with the standard clinical equipment. The “unproductive” time endured when using the standard clinical equipment was notable, leading to the opportunity of increasing clinical efficiency.

P84

The relationship between electrical auditory brainstem responses and perceptual thresholds in Digisonic® SP cochlear implant users

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Aim
Determining the electrical stimulation levels is often a difficult and time consuming task because they are normally determined behaviorally—a particular challenge when dealing with pediatric patients. The eSRT and the ECAP have already been shown to provide reasonable estimates of the C and T-levels, although these estimates tend to overestimate the C and T-levels. The aim of this study was to investigate whether the eABR can also be used to reliably estimate a patient’s C and T-levels.

Material and methods
Behavioral C and T-levels were taken directly from each patient’s existing MAP file for their standard ‘everyday usage’ program map. eABRS were measured postoperatively on a basal, a medium and an apical electrode.

Results
The correlation between eABR detection thresholds and behaviorally measured perceptual thresholds was statistically significantly ($r = 0.71$; $p < 0.001$). In addition, eABR wave V amplitude increased with increasing stimulation level for the three loudness levels tested.

Conclusions
These result show that the eABR detection threshold can be used to estimate a patient’s T-levels. In addition, wave V amplitude could provide a method for estimating C-levels in the future. The eABR objective measure may provide a useful CI fitting method—particularly for pediatric patients.

P85

High-Resolution EEG investigation of the perceived pleasantness of music in children with unilateral and bilateral cochlear implants

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Presenting Author
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Objectives
To investigate by means of non-invasive neuroelectrical imaging (High-Resolution EEG with Source Reconstruction) the perceived pleasantness of music in children with unilateral and bilateral cochlear implants (CI), and to compare the results to those obtained in a reference group of normal-hearing (NH) children.

Background
It is established that bilateral CI affords deaf children advantages over unilateral CI as far as sound source localization and speech perception in competing noise are concerned. However, the benefit of bilateral CI on music perception remain unknown.

Methods
5 NH children and 5 children who received a sequential bilateral CI were assessed by means of High-Resolution EEG with Source Reconstruction as they watched a musical cartoon. Implanted children were tested before and after the second implant. For each subject the scalp Power Spectral Density was calculated in order to investigate the EEG alpha asymmetry.

Results
The scalp topographic distribution of the EEG power spectrum in the alpha band was different in children using one CI as compared to NH children. With two CIs the cortical activation pattern changed significantly, becoming more similar to the one observed in NH children.

Conclusions
The findings of the present study support the hypothesis that bilateral CI users have a closer-to-normal activation of cortical areas mediating the pleasantness of music perception as compared to unilateral CI users.

P86

Temporal Properties of the Auditory Nerve in Pediatric Cochlear Implant Recipients

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No conflicts to be reported.

Objectives
To investigate temporal response properties of the auditory nerve in children with auditory neuropathy spectrum disorder (ANSD) and children with sensorineural hearing loss (SNHL).

Background
Temporal response properties of the auditory nerve have been evaluated for adult cochlear implant (CI) users. However, no study has investigated these properties in pediatric CI users. More importantly, these properties have not been characterized in children with ANSD. This project addresses these needs.

Methods
25 children with ANSD and 25 children with SNHL ranging in age between 4.1 to 17.8 years participated in this study. All subjects had at least 12 months of experience with Cochlear Corp devices. Temporal response properties of the auditory nerve were evaluated by measuring amplitudes of the electrically evoked compound action potentials (ECAPs) in response to individual pulses in a pulse train delivered at four different rates: 500, 900, 1800, and 2400 pps per channel. ECAPs were recorded for an apical, mid-array and basal electrode for each subject.

Results
ECAPs recorded from 14 children with ANSD and 21 children with SNHL showed typical temporal response patterns as described in the literature. However, ECAPs recorded in other subjects showed increased amplitudes over the pulse train at all four stimulation rates. These subjects tended to have worse speech and/or language skills when compared to those who showed typical temporal response patterns. **Conclusions**: Differences in the responsiveness of the auditory nerve may contribute to across-subject variation in speech perception performance in pediatric CI users.

P87

Cortical Auditory Evoked Potentials in Bilateral Cochlear Implant Users and Listeners with Bimodal Hearing

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This work was supported by grants from the MED-EL Hearing Solutions (MHS) Research Grants.

Objectives
To investigate the feasibility of measuring the binaural interaction component (BIC) of the cortical auditory event-related potential (ERP) in bilateral cochlear implant (CI) users and listeners with bimodal hearing.

Background
To date, no study has systematically investigated the BIC of the ERP in any bilateral CI users. More importantly, it is still unknown whether this response can be recorded from listeners who use a CI in one ear and a hearing aid in the other ear (i.e. bimodal hearing). This project addresses these needs.

Methods
The BIC of the ERP was recorded in adult and child subjects with bilateral CIs using a multi-channel Neuroscan system. This response was also recorded from adult subjects with bimodal hearing using a multi-channel custom-made system. In bilateral CI listeners, the stimulus was a 100-ms train of biphasic current pulse delivered to individual electrodes at the C level. For bimodal listeners, the stimulus was a 100-ms broad-band Gaussian noise presented at 70 dB SPL. The ERP was recorded in response to left monaural, right monaural and bilateral stimulation for each listener. The BIC of the ERP was computed by subtracting the ERP recorded in response to binaural stimulation from the algebraic sum of the two monaural evoked potentials.

Results
The preliminary data show variations in morphology of the BIC in different groups of listeners. Conclusions: It is feasible to measure the BIC of the ERP from bilateral CI users and listeners with bimodal hearing.

P88

Cross-Modal-Plasticity in deaf and deafblind children: a study with Evoked Potential before and after Cochlear Implants

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Abstract
Enter the abstract here. Word count does not include title and authors/institutions.

Objectives
To evaluate on Cross-Modal-Plasticity before and after Cochlear Implants (CI).

Background
Significant neuroplastic changes occur in deaf and blind as a result of impairment sensory that affects them, however little is known about somesthetic cortical reorganization in deaf-blind children.

Methods
Evaluation of the maps topography of Visual Evoked Potentials (VEP) and Somatosensory by stimulation of median (SSEP-N20) and tibial (SSEP-P40) nerves. In addition, we obtained Cortical Auditory Evoked Potential (CAEP).

Results
Topographic distribution maps of the SSEP-N20 showed expansion of activation, although in deaf children the over-representation was less extensive -area temporal in deaf and areas temporal-occipital in deafblind children were activated. SSEP-P40 no showed changed -strictly localized in area of somesthetic information representation of the foot. Maps topographic of the VEP no showed changes. Also offered for the first time, evidence of Cross-Modal-Plasticity through a study Post-IC. Deaf and deafblind children who are implanted after 7 years of age if there are changes in the SSEP-N20 in the study Pre and Post-CI. While that with the responses of the obtained Cortical Auditory Evoked Potential was possible to evidence the cortical activation by the auditory sensory input through the CI.

Conclusions
The expansion of the cortical response of the SSEP-N20 to the left temporal region in deaf and deafblind children with 7 o more age was interpreted as evidence of Cross-Modal-Plasticity, effect that may to have the use of the hands for communication in these children, with consequent implications to the optimal use of the CI during rehabilitation auditory.

P89

Exploring the Electrode-Neuron Interface using the Electrically Evoked Compound Action Potential, Computerized Tomography, and Behavioral Measures

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Speech perception scores vary widely among cochlear implant listeners. Part of this variability is likely due to the electrode-neuron interface; defined as electrode position, bone and tissue growth following implantation, and the integrity of auditory neurons. In the present study we applied three metrics to

assess this interface: the electrically evoked compound action potential (ECAP), behavioral thresholds using focused stimulation, and computerized tomography (CT) to estimate electrode position. As it is not currently possible to measure neural density of auditory neurons, the aim of combining these measures is to make predictions about neural status. Eight adult, cochlear implant listeners with the Advanced Bionics HiRes90k device participated. For all available electrodes, behavioral thresholds were collected using quadrupolar stimulation, and channel interaction functions were constructed using the ECAPs elicited with monopolar stimulation. Preliminary results suggest across all subjects ECAP amplitude was significantly correlated with both behavioral thresholds and electrode position; smaller ECAP amplitudes were observed for higher behavioral thresholds and distances further from the modiolus. However, we did not observe consistently higher thresholds for electrodes distant from the modiolus as has been demonstrated by others. The long-term goal of this research is to provide an ECAP protocol for audiologists; such a protocol maybe used in individualized programming to optimize neural stimulation via assessment of the electrode-neuron interface.

Author Index

(Open Papers and Posters)

Author Index – Open Papers and Posters