ABSTRACTS

ORAL SESSIONS

S1

CALIBRATION OF STIMULI USED IN ABR AND ASSR

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An international standard, ISO 389-6 for reference hearing thresholds was presented in 2007 for signals of short duration. Data for these stimuli were limited to the so called reference signals: an acoustic click based on a 0.1 ms electric square wave and a tone-burst based on the 2-1-2 envelope (H. Davis). Most clinical ABR devices on the market have still their factory calibrated reference values, and thus the calibration values may vary between companies. No standard reference values have been developed for the more complex ASSR stimuli, and either factory calibrated values or your own psychoacoustic references have to be used. For the system where several tonal stimuli are presented simultaneously, the total stimulus is extremely complex, and each of the tonal components might be presented alone for this calibration procedure. When bringing the stimulus complex together during the actual measurements, another more broadband stimulation of the auditory system may be expected. Each single modulated ASSR stimulus may be regarded as tone-bursts with a high repetition rate, and ISO 389-6 presents correction values with different rates, up to 100 Hz, but so far only for clicks. A recent publication has presented these correction values also for tone-bursts, but it is difficult to see if this may be used for calibration purposes. The proposal at present is to make your own local psychoacoustic calibration until a standard for calibration of ASSR stimuli will arrive.

S2

MULTIPLE ASSRS (80-HZ AC STIMULI) IN INFANTS AND YOUNG CHILDREN WITH HEARING LOSS

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Multiple 80-Hz auditory steady-state responses are a promising technique for threshold estimation in infants, but additional data are required, especially for infants and children with hearing loss. Recently, we (Van Maanen & Stapells, JAAA, in-press 2009) reported multiple-ASSR results for 54 infants with normal hearing (as indicated by tone-evoked ABR), and recommended "normal" AC-ASSR levels to be 50, 45, 40 and 40 dBHL at 500, 1000, 2000 and 4000 Hz, respectively. In the current study, we assess these "normal" levels in infants with hearing loss and compare multiple-ASSR thresholds (in dB HL) to estimated behavioural thresholds (in dB eHL; BCEHP) predicted by tone-ABR. Multiple-ASSR results (AC stimuli) were obtained for 68 infants (median age = 14.6 mos) with hearing loss confirmed by tone ABR. ASSR thresholds were determined in 37 of these infants. ASSR threshold results from 29 normal infants from our previous study were also included. RESULTS: Out of 337 tests with elevated ABR thresholds, the ASSR was "normal" in only 14 tests. In these 7 infants, other ASSR frequencies were elevated and thus the infants would not have "passed" the ASSR. Multiple-ASSR thresholds were highly correlated with ABR-predicted eHL thresholds, with correlations (excluding "no-response" results) of .81, .73, .84 and .85 for 500, 1000, 2000 and 4000 Hz, respectively. (Correlations including "no-response" results were .97 to .99.) Mean (± 1SD) difference scores (ASSR minus ABR eHL, all data) were 17.2±10.9, 13.4±10.4, 9.6±8.1 and 4.0±9.9 dB for 500, 1000, 2000 and 4000 Hz, respectively. CONCLUSIONS: The "normal" AC-ASSR levels above differentiate infants with normal hearing from infants with hearing loss. Correlations and difference scores indicate a strong relationship between tone-ABR and multiple-ASSR thresholds. Results are quite promising; nevertheless, additional data are required (i.e., more infants with a full range of hearing loss) before we can depend solely on ASSR.

S3

DETERMINATION AND EVALUATION OF CLINICALLY EFFICIENT STOPPING CRITERIA FOR THE MULTIPLE AUDITORY STEADY-STATE RESPONSE TECHNIQUE

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Background: Although the auditory steady-state response (ASSR) technique utilizes objective statistical detection algorithms to estimate behavioural hearing thresholds, the audiologist still has to decide when to terminate ASSR recordings introducing once more a certain degree of subjectivity.
Aims: The present study aimed at establishing clinically efficient stopping criteria for a multiple 80-Hz ASSR system.
Methods: In Experiment 1, data of 31 normal hearing subjects were analyzed off-line to propose stopping rules. Consequently, ASSR recordings will be stopped when (1) all 8 responses reach significance and significance can be maintained for 8 consecutive sweeps; (2) the mean noise levels were ≤ 4 nV (if at this "≤ 4-nV" criterion, p-values were between 0.05 and 0.1, measurements were extended only once by 8 sweeps); and (3) a maximum amount of 48 sweeps was attained. In Experiment 2, these stopping criteria were applied on 10 normal hearing and 10 hearing-impaired adults to asses the efficiency.
Results: The application of these stopping rules resulted in ASSR threshold values that were comparable to other multiple-ASSR research with normal hearing and hearing-impaired adults. Furthermore, in 80% of the cases, ASSR thresholds could be obtained within a time-frame of 1 hour. Investigating the significant response-amplitudes of the hearing-impaired adults through cumulative curves indicated that probably a higher noise-stop criterion than "≤ 4 nV" can be used.
Conclusions: The proposed stopping rules can be used in adults to determine accurate ASSR thresholds within an acceptable time-frame of about 1 hour. However, additional research with infants and adults with varying degrees and configurations of hearing loss is needed to optimize these criteria.

S4

STEAD-STATE MEASUREMENT AND ANALYSIS APPROACH TO PROFILING AEPS FROM SHORT- TO LONG-LATENCY: UNDERLYING CONCEPTS AND RESULTS IN ADULTS

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Abstract not available.

Abstract not available

S5

AUDITORY TEMPORAL PROCESSING IN DYSLEXIA: AN ASSR STUDY.

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Developmental dyslexia refers to a deficiency in reading and writing skills, caused by a deficit in the development of phonological skills. It is hypothesized that the phonological problems in dyslexia result from a fundamental deficit in low-level auditory temporal processing, in turn causing a subtle deficit in speech perception.
In the present study, temporal envelope processing was investigated in a group of normally reading and dyslexic adults by means of auditory steady-state responses (ASSRs), in combination with cognitive and psychophysical measures. Multichannel ASSRs were evoked by speech-weighted noise stimuli that were 100% amplitude-modulated at 4, 20 and 80 Hz. Listening conditions were degraded by adding masking noise or lowering modulation depth. Furthermore, reading tests and a psychophysical AM-detection task were conducted.
The aim of this study is to try to trace at what level of the auditory system (brainstem or cortex) possible neurophysiological differences between normally reading and dyslectic subjects occur. Furthermore, we want to investigate whether dyslectic subjects have a deficit in temporal envelope processing, in optimal listening conditions or only in degraded conditions. Finally, we examine the relation between neurophysiological and psychophysical indicators of auditory temporal processing and speech perception.
Preliminary analyses suggest comparable neurophysiological temporal envelope processing for both groups at 80 Hz. In contrast, dyslexic subjects tend towards deficient processing at 20 Hz when masking noise is added. Correlations between psychophysical and ASSR measures indicate that both are related mechanisms. Results will be discussed at the conference.

S6

MEASURING TRAINING-INDUCED AUDITORY PLASTICITY USING AUDITORY STEADY-STATE RESPONSES

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Abstract: Re-mapping of the primary auditory cortex may be induced by extensive training. For example, training of monkeys to perform frequency discrimination at one carrier frequency expands the representation of that frequency region in the auditory cortex. This study was intended to demonstrate training-induced auditory plasticity using auditory steady-state responses (ASSRs) in humans. Right-handed, non-musicians underwent auditory training in their left ear at one frequency only.. The training was performed using either frequency discrimination (FD, experiment1), frequency modulation detection (FMD, experiment 2), or amplitude modulation detection (AMD, experiment 3). ASSRs were recorded to 1-, 2- and 4-kHz amplitude modulated tones. ASSRs recorded at the start of the experiment were compared with the ASSRs recorded after three two-hour sessions of training scheduled 24 hours apart. The results revealed significant increase in the amplitude of 40-Hz ASSRs (but not 80-Hz) recorded to amplitude modulated tones presented at trained frequency to the trained left ear. No other differences were observed between any other pre- and post-training pair. These results support the idea of training-induced reorganization of the auditory cortex (but not the brainstem).

S7

THE DECOMPOSITION OF THE TRANSIENT EVOKED OTOACOUSTIC EMISSION TO PRIMARY COMPONENTS

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Background: Recently, the algorithm for decomposition of the transient otoacoustic emissions signal to primary components was proposed. This algorithm uses the transformation of the signal to nonlinear time grid based on the space invariance hypothesis. We expected that in this grid the signal can be represented as a convolution of certain pattern and a sequence of several 'events'. In this case the pattern as well as a set of events can be separated using certain modification of blind deconvolution technique.

Aim and methods: To evaluate the event sequence we use the deconvolution algorithm regularized by l1 norm. A new method for adaptive regularization of signal acquired to several buffers was developed. This method reduces the number of false positive events by about 5 times for typical conditions.

For re-evaluation of pattern by the event sequence the deconvolution with regularization of the first derivative by means of spectrum sharpening was used.

Results: It was found that this regularization does not affect the shape of predicted patterns. In iterations, two abovementioned deconvolutions are applied. During these iterations, the initial estimation of pattern obtained from cepstrum averaging for a large group of cases is refined for particular measurement. In these iterations, an estimator for long-term OAE components is also implicated.

To take into account the deviation of real ear from time invariance hypothesis the correction procedure based on phase filter was used. This correction can be individually tuned by optimization procedure which uses the splitting of event due to latency deviation as a criteria.

Conclusion: In contrast to the previously reported data, the modified algorithm permits not only to obtain the mean pattern for a large group of cases, but also to decompose each single measurement. The preliminary results of this decomposition are discussed.

S8

CHANGES IN DISTORTION PRODUCT OTOACOUSTIC EMISSION LEVEL OBTAINED OVER CONTINUOUS FREQUENCY BANDS USING CONTRALATERAL NOISE

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Changes in human distortion product otoacoustic emission (DPOAE) level were measured over continuous frequency bands in response to activation of the medial olivocochlear (MOC) efferent system by contralateral broadband noise. DPOAEs were obtained using continuous upward ramps of the lower frequency tone, f1, while the higher frequency tone, f2, was fixed. These ramps were designed to change the stimulus frequency ratio f2/f1 over a fixed range for each fixed f2 value of 2, 3, and 4 kHz. Contralateral noise was presented on alternating ramps and the DPOAEs with and without contralateral noise were averaged separately. Data was collected for 29 young adults (aged 19 to 33 years) and 16 children (aged 8 to 13 years). The adults and half the children had normal hearing, whereas the other eight children had Auditory Processing Disorders. Stimulus frequency ratios of 1.10 and 1.22, and noise levels of 60 dB SPL (all participants) and 50 dB SPL (adults only) were employed. Changes in DPOAE level were generally suppression (a reduction in DPOAE magnitude), but enhancement was also observed. For most participants, changes were evident for much of the frequency ranges tested. DPOAE nulls were observed and a common response pattern was a shift of emission morphology to higher frequencies with contralateral acoustic stimulation. Changes were smallest at 4 kHz, especially for the wider stimulus frequency ratio. Average results were similar across participant groups. The method appears promising for relatively rapid evaluation of the MOC efferent system in humans and offers information complementary to measurement strategies that explore the effects of stimulus level.

S9

INFLUENCE OF UNILATERAL TINNITUS ON DISTORTION PRODUCT OTOACOUSTIC EMISSION (DPOAE) LEVELS

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It has been suggested that the presence of a limited area of damaged outer hair cells (OHCs) with intact inner hair cells, which may not be detected on the conventional audiogram, results in unbalanced neural activity between Type I and Type II fibers leading to tinnitus. In normal-hearing tinnitus patients, DPOAEs provided ambiguous data of OHC function when compared to non-tinnitus controls. Hearing loss in the extended high-frequency (EHF) region may decrease DPOAEs evoked at lower frequencies. Results of EHF audiometry in tinnitus patients are limited. The aim of the study was to evaluate DPOAEs and EHF thresholds in normal-hearing patients reporting unilateral tinnitus in left ear. Thus, each subject acted as their own control.

Data were obtained for 26 subjects with bilateral hearing thresholds <25 dB HL from 0.25 to 8 kHz and <70 dB HL at 10, 12.5, 14, and 16 kHz. The DP-grams were measured in the 0.5-8 kHz range using 65/55-dB SPL primaries and f2/f1=1.2. The data analyses included DPOAEs with S/N>3 dB.

Median audiometric data showed that thresholds in the left ears were significantly higher than those in the right ears at all four EHFs. Mean DPOAE levels of the left ears were lower than those of the right ears in the frequency range above 1 kHz. Additionally, a paired-comparison test of DPOAE levels of each patient's right and left ear revealed significant differences at 6 and 8 kHz.

The results indicate that: 1. OHC impairment in the most basal region reduces contribution to more apically generated DPOAEs; 2. OHC impairment in a limited area, which may be revealed by DPOAEs but not by conventional audiometry, can contribute to tinnitus generation; and 3. patients with unilateral tinnitus and normal hearing on the conventional audiogram are likely to demonstrate hearing loss in the EHF region.

S10

MATCHING PURSUIT ALGORITHM APPLIED TO THE EVALUATION OF CLICK-EVOKED OTOACOUSTIC EMISSIONS RECORDED WITH LINEAR AND NONLINEAR PROTOCOLS

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Typically, click-evoked otoacoustic emissions (CEOAEs) are analyzed using fast Fourier transform which has greatly limited time-frequency (t-f) resolution. The purpose of the present study was to process CEOAEs recorded using linear and non-linear presentation modes by applying the Matching Pursuit (MP) method of adaptive approximation which provides a high t-f resolution. The data were recorded in 26 normal-hearing subjects using the ILO96 system with clicks presented at 78-82 dB pSPL. In the non-linear mode, a series of four clicks was delivered with three at the same level and polarity and the fourth three times greater in amplitude and inverted in polarity, whereas in the linear mode all stimuli were presented at the same level and polarity. The responses consisting of 512 data points were stored in two buffers. For each subject, 520 responses were recorded separately for off-line MP analyses. The MP method allowed decomposition of signals into waveforms of defined frequency, latency, time span, and amplitude and also identified patterns of resonance modes that were characteristic for CEOAEs recorded in each individual ear. The overall CEOAE levels were higher by 4 dB for the linear mode than those for the nonlinear method, in agreement with studies reported previously. In general, t-f properties of CEOAEs recorded with linear and non-linear protocols were similar with the exception of the 0-6-ms post-stimulus time window and the frequency range below 2.2 kHz. This part of the signal was contaminated by a stimulus artifact in the linear mode. The reproducibility factor grew faster with an increase of the number of averaged responses for the linear protocol than for the non-linear method. The results suggest that main differences between CEOAEs measured with the two methods are related to stimulus artifacts occurring at the beginning of the recording time-window in the linear mode.

S11

ANALYSIS OF EFFECTIVENESS OF HEARING SENSITIVITY EVALUATION BY OAE AND ASSR AUTOMATED ALGORITHMS

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The objective of the study was to evaluate the effectiveness of hearing threshold estimation by the use of automated acoustical protocols (Cochlea-Scan) and auditory steady-state responses (ASSR), and to test the applicability of these methods in hearing screening programs of pre-school and school age children.
A group of normal-hearing and hearing-impaired subjects with mild to moderate hearing losses were used in the study. The group included adults and school-age children selected from the population of schoolchildren tested in a universal screening program. Hearing threshold levels were assessed by pure tone audiometry (PTA), the Cochlea-Scan (Fischer-Zoth/Natus) DPOAE protocols, and ASSR threshold measurement. The BioLogic Master electrophysiological system was used in ASSR tests, and PTA threshold prediction was based on an optimized algorithm derived in previous investigations by the authors.
The data from this study indicate that concurrent application of acoustic and electrophysiological tests gives a fairly accurate assessment of hearing sensitivity in both normal-hearing and in hearing-impaired subjects. The margin of assessment in the hearing impaired group was found to be closer to a PTA value then in normal hearing group. Assessment error can be further reduced by applying improvements in OAE measurements and better estimation of ASSR threshold. Implementation of combined electrophysiological and acoustic test protocol is proposed for a new device being developed.

S12

LONG-TERM REPRODUCIBILITY OF TEOAES IN VARIABLE TIME-FREQUENCY REGION

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The objective of the study was to investigate any stable patterns in the time-frequency structure of otoacoustic emissions, in a population of 51 healthy adults sampled over one year period. Material and Methods: TEOAE recordings were collected from 51 ears in subjects presenting normal hearing and normal impedance values. The responses were analyzed by a TF (time-frequency) algorithm using WVD (Wigner-Ville Distribution). The TF region of analysis was optimized by examining the content of various rectangular and triangular TF regions. The TEOAEs from the pre and 12 month post-recordings were compared. Results: The advantage of the time-frequency transformation over the traditional FFT analyses was highlighted by a comparison of the correlation index of the TEOAE waveforms and correlation indices estimated from the T-F maps. The TEOAE correlations were estimated as: (i) For the 2.42ms-20ms window, range of corr.: (-0.23;0.94) with a mean = 0.47+/-0.29 s.d. ii) For the optimal area for TF analysis, 2.42 ms-6.72 ms,: range of corr. (-0.41; 0.86), with a mean corr. = 0.49+/-0.32 s.d. The correlation index estimated from the rectangular TF bitmap area with the same two perpendicular sides as the optimal triangle (time from 2.24 to 6.72 ms, frequencies range from 2466 Hz to 5250 Hz) is equal to 0.504. This value is significantly lower ($p<0.0002$) than that for the triangular region where the correlation is equal to 0.538. Conclusions: The WVD is a purely non-parametrical form of TF analysis, it provides a not manipulated picture of the TEOAE signal. Longitudinal personal similarity and the interpersonal diversity of spectrograms showed individual anatomical conditions of the signal transmission to the external canal. Applying time varying, triangular region, the analysis improves the reproducibility significantly. The pairs of distribution localized in the optimal triangle of the T-F plane are better correlated then those in the rectangular region.

S13

AUDIOLOGICAL FIINDINGS IN CHILDREN WHO HAD HYPERBILIRUBINEMIA ON BIRTH

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Neonatal period is often marked with hyperbilirubinemia, which can be responsibile for auditory perception disorders. Recent researches showed that high bilirubin level may have toxic effects on CNS and laed to hearing or visual impairment, hypotonia, disarthira and different clinical forms of muscular tension.

The research aim was to examine the level of auditory perception development in children with speech language disorders in relation to the presence of hyperbilirubinemia on birth. The research sample comprised 30 children with speech language disorders, at the age from 5 to 7, and it was divided into two groups: Experimental group (E=15) consisted of children who had hyperbilirubinemia on birth, and Control group (C=15) consisted of children who had no hyperbilirubinemia on birth. All children are on continous audiolinguistic treatment in Institute for experimental phonetics and speech pathology (IEPSP) in Belgrade. Research methods included: 1. analysis of anamnestic data; 2. audiological diagnostics (TEOAE, DPOAE, tympanometry and pure tone audiometry); 3. estimation of phoneme hearing and voice pronunciation by the IEPSP test battery.

Research results are presented in relation to comparative analysis of obtained findings from examined groups of children.

Key words: hyperbilirubinemia, auditory perception, audiological diagnostics.

S14

EAR PROBE DESIGN FOR INFANTS AND ADULTS

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Any audiometric test relies on a known stimulation of the ear(s), and some need to record sound within the ear canal, such as otoacoustic emissions (OAE). Ear probes can serve for both generating and recording sound in the human ear canal. For different test methods, a probe must fulfill specific needs, such as frequency range, maximum sound level that can be generated or recorded, microphone noise, nonlinear distortions, sealing requirements, robustness against static pressure. Additionally, the probe must be robust and easy to use and clean, which influences mechanical design and the concept of probe body and ear tip.
Calibration of both stimulus and response is needed for reliable results in most audiometric methods. Ear probes are usually calibrated to the individual ear canal by using the feedback signal of the stimulus as picked up by the probe's microphone. However, besides the algorithmic techniques used, probe geometry and coupling to the ear play important roles in individual calibration. While for newborns, due to their small ear canals, calibration is rather simple, resonance effects occur in longer ear canals. Moreover, these effects have a huge interindividual variance. Additionally, the ear tip geometry influences near field effects from speaker outlet to microphone inlet openings. The signal that results from this path is not always clearly discriminable from the desired feedback signal, representing the ear canal sound pressure.
The presentation aims at showing how universal an ear probe can be and where the limits are in providing reliability, usability and accuracy.

MODIFIED AUDITORY BRAINSTEM RESPONSES MEASUREMENT IN AUDITORY NEUROPATHY/ DYS-SYNCHRONY

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Auditory neuropathy/ dys-synchrony (AN/AD) clinically presents with speech perception disproportionate to pure tone audiometry. It is characterized by absent or atypical brain stem responses (ABR) and recordable otoacoustic emissions (OAE) and/or cochlear microphonics (CM). Several subtypes exist, dependent on etiology and on the site of lesion: Inner hair cells, synaptic junctions, spiral ganglion cells and type I afferent fibers can be involved. Otoacoustic emissions can disappear in AN/AD, so that invasive CM measurement becomes neccessary for confirmation of diagnosis. Differential diagnosis gets especially meaningful when cochlea implantation is taken into consideration.

The first aim of this work was to modify our ABR protocol to enable a non-invasive diagnostic tool as an alternative to CM when AN/AD is suggested, but no (more) OAE are dectectable. The second aim was to get further information for audiological subtyping of AN/AD.

We performed ABR measurements with a constant rarefication and condensation stimulus, a reduction of the click-rate and with a chirp-stimulus additionaly to the conventional ABR recording in 8 children with AN/AD (7 unilateral) and otoacoustic emissions.

Our results show that with the modified stimuli syncronization could not be remarkably optimized. But interestingly, in 6 of the 8 patients, regardless of the type of stimulus, a wave V at levels below the ABR threshold could be found, whereas higher levels showed no wave V. The results indicate that a better synchronization at lower stimulus levels could be characteristic for some patients with AN/AD.

S16

THE ACOUSTIC CHANGE COMPLEX AS A MEASURE FOR ELECTRODE DIFFERENTIATION IN COCHLEAR IMPLANT USERS

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The Acoustic Change Complex (ACC) is an auditory evoked potential in response to acoustic changes. It can be interpreted as an electrophysiological measure of the neural processes that underlie the detection of a change in an ongoing acoustic signal. Recently, it was shown that the ACC can be measured in cochlear implant subjects with electrical stimulation of the auditory nerve. The aim of our study was to investigate the ACC in response to subsequent stimulation of neighbouring intracochlear electrodes and to compare the ACC with psychophysical discrimination abilities.
Ten adult subjects provided with a nucleus freedom cochlear implant (CI) and with at least 6 months of CI experience took part in the study. Electrophysiological measurements were recorded on eight electrodes placed on the scalp. Stimuli consisted of 1.5s stimulation on one electrode immediately followed by stimulation for 1.5s on the next neighbouring electrode in apical direction. Stimulation levels were adjusted to achieve identical loudness perception (adjusted on 'loud' via categorical loudness scaling). For each subject, ACC recordings were performed on three electrode pairs: 3/4 (basal), 10/11 (mid), and 18/19 (apical). Additionally, the psychophysical differentiability (D'-measurements) for each electrode pair was measured by a 3-AFC paradigm.
Due to electrical artefacts caused by the CI usually some electrodes were disturbed. An ACC was identified as detected when on three electrodes a response was observable. Using this criterion, the ACC was detectable in 72% of the measurements. Detectability of the ACC varied more across subjects than across intracochlear electrode location. ACC amplitudes correlated with psychophysical D' measurements significantly ($r=0,65$, $p<0,01$).
The measurements support the hypothesis that the ACC provides an electrophysiological measure of discrimination abilities. It may be also used for evaluation of cochlear implant performance.

The study was supported by a grant from Cochlear Ltd., London, UK

S17

SHORT AND MIDDLE-LATENCY AUDITORY RESPONSES IN CHILDREN WITH PHENYLKETONURIA HAVING UNDERGONE EARLY DIAGNOSE AND TREATMENT: PRELIMINARY RESULTS

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Phenylketonuria (PKU) is a genetic disorder that causes biochemical alterations in the central nervous system and thereby hindering the myelination process and leading to a deficiency in the synthesis of proteins and neurotransmitters. Such changes in myelin structure and function might alter patterns of neuronal conductivity and/or diminish permanent synaptic connection in PKU patients. Ideally, dietetic treatment should be performed within the first weeks of life to avoid clinical and biochemical manifestations of the disease. When the diet is continually maintained, children with phenylketonuria experience normal development. However, deficits in executive functions and interhemispheric interaction have been observed even in children that began early, uninterrupted treatment. This study was designed to evaluate the main alterations on the peripheral and central auditory pathway in phenylketonuria children with early diagnose and treatment, and compare the results with age- and gender-matched normal children. Audiometry, acoustic immitance tests, auditory brainstem responses (ABRs) and middle latency responses (MLRs) were conducted in a control group of 15 infants with no hearing disorders (median age of 11.3 years) and a study group of 16 PKU infants (median age of 9.9 years). The median for the days of life when treatment started was 22 days. Clinically significant hearing losses were not observed in any group. Acoustic reflexes showed higher thresholds in 1000 and 2000 Hz in PKU children. There were ABR latency differences among groups, wherein the PKU group had later waves III and V and longer I-III and I-V interpeak intervals. Wave Pa of the MLR also was later in the PKU group. These preliminary results suggest that the auditory pathway is compromised even in early treated PKU children.

S18

IMPROVED DETECTION OF ABR REPEATABILITY

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Background: One challenge of clinical Auditory Evoked Potential (AEP) measurement is determining whether specific features of the AEP waveform represent electrophysiological responses or noise. Common practice is to obtain two averaged waveforms representing responses from independent sets of stimuli and assessing their repeatability, either subjectively or statistically such as with a correlation coefficient. However, comparison of two independent averages is not a statistically reliable indicator. A more robust statistic is obtained with a Monte Carlo technique: all individual responses are randomly reordered, for each random order two halves of the response data are correlated; the average correlation is used as the indicator of a repeatable response.

Aim: To apply this Monte Carlo technique to automated ABR detection in an infant screening protocol and assess its performance.

Method: 153 infants enrolled in an infant hearing screening program were tested following an initial screening with the Natus Algo(r) AABR (pass/refer rates 72%/28%). ABR responses (35 dBnHL clicks, 7.5 minutes maximum) were subsequently collected from each infant in three tests: Right Ear, Left Ear and No-Stimulus. Statistical repeatability measures from no-stimulus tests were analysed to determine an appropriate AABR detection threshold ($p<0.02$) using correlation statistics with and without the Monte Carlo technique (average of 100 reorderings).

Results: The Monte Carlo technique reduced the correlation threshold from 0.75 to 0.49 and improved the initial screening pass/refer rates from 58%/42% to 69%/31%. In addition, the mean time to decision (+/- standard deviation) was also improved from 7.0 +/- 3.7 minutes to 5.6 +/- 3.4 minutes.

Conclusions: Statistical repeatability detection in automated ABR detection is improved ($\alpha<.05$) using the Monte Carlo technique in a typical infant screening protocol. This technique shows promise for a broad range of clinical and research applications.

S19

OBJECTIVE EVALUATION OF THE UNDERMASKED ABRS TO CLICKS AND HIGH-PASS MASKING PINK NOISE IN PATIENTS DIAGNOSED WITH MENIERE'S DISEASE

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Previous work demonstrated that analyses of ABRs elicited by 60 dB nHL clicks and high-pass masking pink noise can be used to distinguish ears diagnosed with Meniere's disease from those free of the disease. In non- Meniere's disease ears, ABRs are progressive masked as the cutoff frequency of the high-pass masker is lowered from 8 kHz to 0.5 kHz. In Meniere's disease ears, undermasking occurs such that at each successive high-pass masking condition one observes an ABR somewhat similar to the ABR to clicks presented alone. In the previous studies, the quantitative measures used (latency and a special amplitude ratio) focused on wave V and relied on subjective visual peak identification. The progressive masking observed in non-Meniere's disease and the undermasking observed in Meniere's disease ears strongly suggest that a quantitative measure such as the Fsp might provide an additional but wholly objective assessment. The Fsp is a measure related to an estimate of the signal-to-noise ratio (SNR) in an ABR. Thus, we expect that the Fsp value for undermasked responses would be significantly greater than for masked responses.

Using the same subjects and dataset from the previous published works (39 normal-hearing non-Meniere's disease and 23 Meniere's disease), we calculated the Fsp values over a 10 ms response window for each of the high-pass masking conditions. In the non-Meniere's disease subjects, we observed the expected decrease in the Fsp value as the cochlea was progressively masked. At the 0.5 kHz high-pass masking condition, the Fsp value often failed to reach the criterion for response detection. For the Meniere's disease patients, the reduction was much less and typically the Fsp value at the 0.5 kHz high-pass masking condition was larger. Thus, it appears that the Fsp value can be used to distinguish objectively individuals with Meniere's disease.

S20

ADAPTATION OF ABRS IN PRE- AND POST-SYNAPTIC AUDITORY NEUROPATHY: AN HOMAGE FOR MANNY DON

Starr, A; Bhatt, S; Zeng, FG

Averaged ABRs in auditory neuropathy either do not show neural components or show a delayed latency of wave V. We hypothesized that rapid adaptation of auditory temporal processes may account for the absence of ABRs in the grand average of the large numbers of clicks required in averaging. We recorded ABRs to 2/s trains of 20 clicks the latter presented at rates of 72 or 105/s. We tested ten AN subjects; four with presynaptic disorders (*OTOF* mutation), four with postsynaptic disorders affecting other cranial or peripheral nerves (*MPZ, FX* mutations, undefined etiologies), and two with no evidence of neurological disorders. The results showed the clinical ABRs to be show a delayed wave V in all *OTOF ,* one postsynaptic disorder, and to be absent in the five other ANs. The patterns of adaptation of the ABR differed between pre and post synaptic disorders. In both pre and post synaptic disorer the latency of wave V was the shortest to the first click and rapidly prolonged to subsequent clicks. Wave V was absent unpredictably to some of the clicks in the train. These physiological data will be related to psychophysical measures of adaptation.

S21

DIRECT INTRACOCHLEAR STIMULATION TO ASSESS AUDITORY CORTICAL PLASTICITY AFTER RELATIVELY LONG INTERVALS OF SEQUENTIAL IMPLANTATION

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Background: This project is focused on auditory plasticity of the auditory pathways in a group of 30 children (range 2y;5m-8y;6m) after sequential bilateral cochlear implantation with relatively long time intervals between surgical interventions. Previous studies have mainly described auditory plasticity in children with relatively short interval between surgeries (± 1 year). The surplus value of structural clinical application of bilateral CI in the light of cost-benefit, auditory performance and auditory plasticity is still a point of discussion in many countries. Given these, electrophysiological assessment at the brainstem level might clear up the relevance of bilateral electrical stimulation.
Aim: To evaluate plasticity changes on the brainstem level in bilaterally implanted children with a relatively long period between first and second implantation.
Materials and methods: The electrically-evoked auditory brainstem response (EABR) was measured at both implanted sides intraoperatively and 6 and 12 months after the first switch-on. Electrophysiological responses, obtained from both sides (newly implanted side CI2 versus experienced side CI1), were compared within the subject over time with respect to EABR latencies of wave III, wave V and interwave latency III-V. Results and conclusions: Even after 12 months of bilateral implant experience wave V and interwave III-V latencies were significantly prolonged at CI2 compared to the experienced side. However, delayed wave V latencies in the CI2 ear diminishes significantly over time.
Prolonged latencies for the second implant of both wave V and interwave III-V, children with sequential bilateral cochlear implants show a delayed neural conduction in the rostral part of the auditory brainstem on the second implanted side, up to 12 months of bilateral implant experience. To learn more about maturation of the auditory brainstem after sequential bilateral cochlear implantation, long term data is needed. Most recent 24 month data of the whole population will be addressed.

S22

INTRACORPOREAL RECORDINGS OF SLOW VERTEX POTENTIALS: THE COCHLEAR IMPLANT USED AS AN EEG SYSTEM

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Background: Until now, the only EP directly recorded by a cochlear implant is the electrically-evoked compound action potential (ECAP). However, the predictive value of ECAPs on electrical thresholds (T/C-levels) seems to be limited. Several groups focus on electrically-evoked auditory cortical responses (EACRs).
Although longer latency responses are usually obtained with conventional EEG systems, it would be more convenient for CI patient and clinician when EPs are directly recorded and averaged by the implant itself without the discomfort and disadvantages of (extracorporeal) EEG setup, e.g. fixed scalp wirings, environmental noise. The development of an implant that could stimulate, obtain, and average longer latency EPs might enhance the development of automatic objective fitting procedures.
Aims: A feasibility study was carried out to develop a recording paradigm based on neural response telemetry (NRT) functionality of a CI system to (intracorporeally) record EACRs.
Materials and methods: A Nucleus Freedom CI system was used for recording and averaging. A new recording paradigm that concatenates multiple NRT windows was used to enlarge recording time window up to 240 ms. Subcutaneous reference electrodes were used to record EEG, while intracochlear electrodes were used for bipolar stimulation. First, the feasibility of a CI as an EP recording system was investigated by using a second (extracorporeal) implant system to measure EPs of normal hearing subjects, 'in vitro'. Secondly, 'in vivo', data intracorporeally-obtained from CI users were compared to data that was simultaneously extracorporeally-obtained from conventional EEG recordings in same subjects.
Results and Conclusions: Data show that it is feasible to record cortical potentials with a cochlear implant. In contrast to 'in vivo' data, 'in vitro' recordings were more sensitive for external noise. All data showed reproducible responses. Based on the present findings, role of location of subcutaneous recording electrodes, response morphology, clinical application, e.g. automatic processor fitting, and future implant design are addressed.

S23

ELECTRICALLY-EVOKED AUDITORY BRAINSTEM RESPONSES IN CHILDREN WITH SEQUENTIAL BILATERAL COCHLEAR IMPLANTS

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Background: This project is focused on auditory plasticity of the auditory pathways in a group of 30 children (range 2y;5m-8y;6m) after sequential bilateral cochlear implantation with relatively long time intervals between surgical interventions. Previous studies have mainly described auditory plasticity in children with relatively short interval between surgeries (± 1 year). The surplus value of structural clinical application of bilateral CI in the light of cost-benefit, auditory performance and auditory plasticity is still a point of discussion in many countries. Given these, electrophysiological assessment at the brainstem level might clear up the relevance of bilateral electrical stimulation.
Aim: To evaluate plasticity changes on the brainstem level in bilaterally implanted children with a relatively long period between first and second implantation.
Materials and methods: The electrically-evoked auditory brainstem response (EABR) was measured at both implanted sides intraoperatively and 6 and 12 months after the first switch-on. Electrophysiological responses, obtained from both sides (newly implanted side CI2 versus experienced side CI1), were compared within the subject over time with respect to EABR latencies of wave III, wave V and interwave latency III-V. Results and conclusions: Even after 12 months of bilateral implant experience wave V and interwave III-V latencies were significantly prolonged at CI2 compared to the experienced side. However, delayed wave V latencies in the CI2 ear diminished significantly over time.
Prolonged latencies for the second implant of both wave V and interwave III-V, children with sequential bilateral cochlear implants show a delayed neural conduction in the rostral part of the auditory brainstem on the second implanted side, up to 12 months of bilateral implant experience. Most recent 24 month data of the whole population will be addressed.

S24

PRAESURGICAL ELECTRICALLY EVOKED AUDITORY BRAINSTEM POTENTIALS

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Background: Registration of electrically evoked auditory brainstem responses (EABR) is an objective functional method allowing assessment of the auditory nerve fibres function as well as location of the site of an auditory nerve lesion. It was expected that it would contribute considerably to the success rate of cochlear implants by providing a better selection of patients suitable for the implantation. However, being technically demanding, the method has failed to become a routine procedure.
Methods and Patients: Preoperatively we performed EABR in 117 candidates (70 females and 47 males) for cochlear implants. Measurements were done in generally anaesthetized patients. Nicolet Viking IV system and Nottingham University electrical stimulator were used to generate reversed electrical stimuli (intensity: from 200 μA to 1 mA, duration: 200 μs) and to record EABR. The stimuli were applied in 3 ways. In the first group of patients an ordinary needle, insulated up to its tip, was placed on the promontorium, in the second group the gulf club needle electrode was placed in the vicinity of the round window, while in the third group a gulf club electrode was placed on the edge of the round window. The EABR were recorded between the opposite earlobe and the vertex.
Results: Most reliable EABR could be recorded in the third group, while in the other two the success rate was smaller.
Discussion: Reasons for the difference in results among the groups will be proposed and discussed.
Conclusion: The results obtained so far suggest the position and the type of the stimulating electrode are critical. The method may eventually become feasible as a routine procedure.

S25

ELECTRICALLY EVOKED AUDITORY STEADY STATE POTENTIALS IN COCHLEAR IMPLANT USERS

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Auditory steady-state responses (ASSRs) can be evoked by sinusoidally amplitude-modulated tones or by low frequency click trains. The purpose of this study was to confirm that ASSRs from cochlear implant (CI) users can be reliably evoked by electrical pulse trains with a pulse rate in the 40 Hz range. A measurement setup to facilitate recording with scalp electrodes was developed and it was determined to what extent objectively estimated hearing thresholds based on these responses can predict behaviorally obtained threshold levels.
Six CI users with a Nucleus implant were stimulated with pulse trains at rates from 35 to 44 Hz to characterize the influence of various stimulus parameters on the EASSRs. Either a pulse train on one electrode or simultaneous pulse trains on multiple electrodes have been used. To compensate for the influence of the artifacts introduced by the electrical stimulation and the RF transmission, artifact interpolation and artifact estimation were evaluated. To ensure the validity of the EASSRs, (1) on/off responses were recorded, (2) EASSR apparent latency across pulse rates was determined and (3) the amplitude growth of stimulus artifact and response amplitude were compared with each other.
The results demonstrate that EASSRs from CI users evoked by low rate pulse trains can be successfully separated from the artifacts of the electrical stimulation. Response amplitudes and latencies are comparable to the ones obtained in acoustically stimulated normal hearing patients. Hearing thresholds obtained from EASSR growth correlate well with behaviorally obtained threshold levels for CI users.

INVESTIGATING THE RELATION BETWEEN AUDITION AND ATTENTION USING AUDITORY LATE POTENTIALS

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Background: There exists a co-morbidity between central auditory processing disorders (CAPD) and attention deficit. Close to 40% of children having a diagnosis of CAPD have also indication of attention problem (Jutras et al., 2007). Also, close to 80% of children with attention deficit failed central auditory tests (Gascon et al., 1986). At this stage, there is no clinical tool that can be used to distinguish the two disorders.

Aims: The objective of the present study was to examine the relation between attention and audition. The specific aim was to find a neurophysiological marker that can help in differentiating attention deficit from CAPD.

Methods: Nine to twelve year-old children with CAPD, children with attention deficits and children without CAPD and attention deficit participated to the study. Auditory late potentials using an oddball paradigm (Mismatch Negativity - MMN) were recorded with a 128 electrodes system. The stimuli were syllabes, nonverbal complex sounds and tone bursts.
Results: Results showed that some principal components of the auditory late potentials were present in all participants. Amplitude and/or latency of these components were different across the groups. The results were also different across the type of stimuli. The MMN component was not present in all participants, even in the control group.
Conclusion: Clinical implications of the results will be discussed.

References: Gascon, G.G., Johnson, R., & Burd, L. (1986). Central auditory processing and attention deficit disorders. Journal of Child Neurology, 1, 27-33.
Jutras, B., Loubert, M., Dupuis, J.-L., Marcoux, C., Dumont, V & Baril, M. (2007). Applicability of central auditory processing disorder models. American Journal of Audiology, 16, 100-106.

S27

CAN A GAP DETECTION RESPONSE BE MEASURED IN BABIES WITH NORMAL HEARING USING CORTICAL AUDITORY EVOKED POTENTIALS (CAEPS) AND IS THE RESPONSE SYMMETRIC BETWEEN LEFT AND RIGHT EARS?

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Background: Some patients with auditory neuropathy spectrum disorder (ANSD) have difficulty detecting gaps in sounds and this can relate to their speech discrimination ability (Zeng et. al. 1999). With neonatal hearing screening, babies with ANSD are being diagnosed at a much earlier age but we do not yet have the ability to determine whether speech is distorted to them. This makes it difficult for clinicians to make the most appropriate recommendations regarding early intervention.

Aims: This pilot study was performed to establish whether a gap detection response could be recorded in babies with normal hearing using CAEPs. If successful, this could potentially be applied to babies diagnosed with ANSD with the view to predicting problems with speech discrimination.

Methods: Thirteen babies under 12 months of age who passed their automated auditory brainstem response screen at birth were evaluated using CAEP testing. The vowel /ah/ with a duration of 2 seconds was used as the stimulus. The no gap stimulus was randomly interleaved with the same sound containing a 20 ms gap inserted 1 s after stimulus onset. Ears were tested separately using insert earphones and recordings were made at Cz referenced to the right mastoid. Analyses were performed to look at individual peak amplitudes, peak-to-peak amplitudes, peak latencies and inter-peak latencies in order to compare the no gap to 20 ms gap conditions and left and right ears.

Results: A clearly defined onset, gap, and offset response was seen for both ears. Using peak-to-peak amplitude evaluations a significant gap detection response was recorded ($p=0.009$).

Conclusions: It is possible to objectively measure gap detection responses in babies using CAEPs. The notable features of the onset, gap and offset responses will be discussed.

S28

EVOKED POTENTIALS TO AN AUDITORY ILLUSION: BINAURAL BEATS

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Objective: To define brain activity associated with the auditory illusion of 3 and 6 Hz binaural beats in low or high base frequencies, and compare it to the sound onset response. Methods: Event-Related Potentials (ERPs) were recorded in response to unmodulated binaural tones of 250 and 1000 Hz to one ear and 3 or 6 Hz higher to the other, creating an illusion of amplitude modulations (beats) of 3 Hz and 6 Hz, in base frequencies of 250 Hz and 1000 Hz. Tones were 2,000 ms in duration and presented with approximately 1 s intervals. Latency, amplitude and source current density estimates of ERP components to tone onset and subsequent oscillations were determined and compared across beat frequencies at both base frequencies.
Results: All stimuli evoked tone-onset components P50, N100 and P200, followed by oscillations corresponding to the beat frequency, and a subsequent tone-offset complex. Beat-evoked oscillations were higher in amplitude with the low base frequency and to low beat frequency. Sources of the beat-evoked oscillations located mostly to the vicinity of the left lateral and inferior temporal lobe in all stimulus conditions. Onset components were not markedly different across stimulus conditions. P50 had significantly different sources than the beat-evoked oscillations; N100 and P200 sources located to the same temporal lobe regions as the oscillations, but with a more bilateral distribution and an additional frontal contribution.
Conclusions: Neural activity with slightly different volley frequencies from left and right ear converge and interfere in the central auditory pathway to generate beats of neural activity in the left temporal lobe, giving rise to the illusion of binaural beats. These oscillations are larger to low- than to high frequency, congruent with the involvement of the 'volley principle' of neural encoding in this illusion. Potentials recorded to binaural beats are distinct from onset responses.
Significance: Brain activity associated with an auditory illusion can be recorded from the scalp.

S29

YOUNG INFANTS' CORTICAL RESPONSES TO LATERALIZATION NOISE SHIFTS PRODUCED BY CHANGES IN INTERAURAL TIME DIFFERENCE

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Newborns reliably orient to the sound location soon after birth; by age 1 month this orienting disappears until after age 4 months. Clifton and colleagues suggested that orienting by the newborn reflects subcortical-mediated reflexes, which are suppressed by age 1 month; reappearance of orienting then occurs with maturation of cortical mechanisms of sound localization. McEvoy et al (Audiology, 1990) recorded slow cortical N1-P2 responses in adults to lateralization shifts in dichotic noise produced by changes in interaural time differences (ITD). In the current study, we used the same technique in order to assess auditory lateralization in young infants. METHODS: 15 normal infants aged under 4 months (mean=2.5 months) had cortical auditory evoked potentials assessed in response to (i) diotic "onset" noisebursts (0-ms ITD) and (ii) to shifts in continuous lateralized noise (75dBSPL) produced by ITD shifts of ±0.5, ±0.8, ±1,±2,±4 and ±8 ms. Shifts occurred every 2 seconds. Stimuli were presented using insert earphones; infants slept during recordings. For comparison, similar recordings were obtained in 11 normal-hearing adults. RESULTS: Similar to previous research, adults showed clear N1-P2 responses to the lateralization shifts. No responses were seen when ITD-shift stimuli were presented to only one ear (confirming the binaural nature of the ITD-shift responses). Infants also showed significant responses to the ITD-shift stimuli, up to ±1ms, with no clear response to longer ITD shifts. Similar to adults, infant response (P1) latencies to ITD-shifts were approximately 30ms later than their responses to the onset stimuli. CONCLUSION: Young infants (even as young as 1.5 months) show clear evidence of auditory cortical responsivity to lateralization shifts produced by changes in the ITD of continuous noise. The lack of responses to larger ITD shifts may reflect immaturity of lateralization processing and/or reduced responses recorded during sleep. [Supported by NSERC].

S30

EVOKED POTENTIAL MEASURES OF CENTRAL AUDITORY FUNCTION FOLLOWING TRAUMATIC BRAIN INJURY

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Millions of Americans sustain traumatic brain injury (TBI) each year, and millions more are living with long-term disabilities related to TBI. The auditory neural pathway is one of the brain systems vulnerable in head injury. Recent studies have suggested that more than 50% of TBI patients have evidence of impaired auditory processing abilities (e.g. Bergemalm & Borg, 2001; Flood et al., 2005), indicating an important need for central auditory assessment in this growing population. Symptoms of auditory processing problems are also likely to overlap many other cognitive and psychological problems associated with TBI. Brainstem and cortical auditory evoked potentials (AEPs) can be used to examine the neural representation of complex auditory information in speech at multiple stages along the auditory pathway, and may help distinguish between sensory and cognitive processing impairment in individuals who have sustained TBI. Thus far, we have measured neural responses using a battery of AEPs evoked by speech including auditory brainstem responses, P1-N1-P2 cortical potentials, and P3 event-related potentials in 4 individuals who have sustained mild-to-moderate TBI. All of these individuals described symptoms of possible auditory dysfunction. Three of the 4 subjects tested so far have apparently abnormal latencies and/or amplitudes compared to control subjects on one or more of the AEP measures, and evidence of deficits in neural encoding of speech information has been observed at each of the levels of processing across subjects. Results will be discussed for individuals with TBI compared to healthy control subjects, including amplitude and latency comparisons for each of these AEP measures. The possibility of objective measures of auditory processing dysfunction at sensory and/or cognitive stages may hold promise in terms of individualizing rehabilitation approaches (such as auditory training or cognitive-based approaches) in the TBI population as well as other populations with central auditory disorders.

S31

AUDITORY CORTICAL CHANGES IN AUDITORY NEUROPATHY ACCOMPANYING NOISE MASKING: RELATION TO IMPAIRED SPEECH RECOGNITION AND TEMPORAL PROCESSESSING

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Speech perception is compromised in AN beyond that expected for the degree of hearing loss. Moreover, noise masking further compromises their ability to understand speech. We measured auditory cortical activity in 12 normal hearing controls and 8 AN subjects (one pre-synaptic due to *OTOF,* three postsynaptic, and four with undefined site of disorder) to tone bursts in silence and mixed in continuous broadband noise. N100 latency in AN in quiet was delayed and amplitude was reduced compared to the normal group; the extent of latency delay was related to psychoacoustic measures of gap detection threshold but not to audibility. Noise in normal hearing subjects was accompanied by N100 latency delays and amplitude reductions paralleling those found in AN tested in quiet. We suggest that N100 latency to tones may serve as an objective measure of the efficiency of auditory temporal processes. The cortical measure may prove to be of clinical importance as the majority of AN subjects do not have ABRs to permit quantitative estimation of the extent of neural dys-synchrony.

EVALUATION OF P1 LATENCY IN KOREANS

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Introduction: The P1 response is a robust positivity at a latency of 100-300 ms in young children in auditory evoked potential. Over the first 2-3 years of life there is a rapid decrease in latency and the mean P1 latency in normal hearing adults is approximately 60 ms. This study was designed to evaluate the change of P1 latency in Korean.

Materials and methods: Among the patients who visited otorhinolaryngology from June 2007 to September 2008, P1 study was performed for 56 normal hearing group and 28 deaf group (16 pre-cochlear implantation group and 12 post-cochlear implantation group). The distribution of groups was 2~17 year of age in the normal hearing group, 2~12 year of age in the deaf group, each. A synthesized consonant-vowel syllable (ba) was used to elicit evoked responses. Evoked responses were collected using the center of frontal head. For each subject, an individual grand average waveform was computed by averaging the ten records. The P1 was identified visually as a robust positivity in the waveform.

Results: For the normal hearing group, P1 latency showed the pattern of shortening as age increases (Coefficient = -.758, $p<0.001$), while for the pre-cochlear implantation group there were a few cases not forming the wave form in P1 latency and the rest showed delayed tendency of latency. For the post-cochlear implantation patients, regular wave form was observed and P1 latency showed less delayed tendency than for the pre-cochlear implantation group (Coefficient= -.713, $p=0.021$).

Conclusion: This study showed that P1 latency decreases as age increases. An establishment of standard value of P1 latency at each age in normal hearing group in Korean is essential for evaluating the central auditory system in the deaf and postCI patients.

OBJECTIVE DETECTION OF THE CORTICAL N1-P2 RESPONSE USING MEASUREMENT OF SIGNAL TO NOISE RATIO

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In order to provide an objective measurement of the confidence in the presence of an N1-P2 cortical response, the response signal to noise ratio (s/n) is one of the many parameters that can be measured. However in order to associate a given value of s/n with a level of statistical confidence of response presence we need to determine the number of degrees of freedom of the measurement and that process is problematic. An alternative method is to obtain the distribution of s/n in a population in which we know that no response is present and then choose a value of s/n that corresponds to our desired level of confidence. A panel of normal volunteers were tested using our standard cortical protocol but without a stimulus present and an automated s/n calculation was made in a total of 936 averages. The correlation between sub-averages and residual noise in the waveform were also computed. When a response is present there is a strong relationship between s/n and correlation whereas in the no-stimulus condition we found only a weak relationship ($R^2 = 0.11$), suggesting that there is likely to be an advantage in employing both of these measurements in calculating the p value. In clinical tests the values of s/n and correlation of a given waveform are now combined to form a composite variable and the p value of the response is computed from reference to the distribution of results of no-stimulus trials. Examples of the application of this technique to the identification of N1-P2 response detection will be presented.

OUTCOMES OF A RANDOMISED CONTROLLED TRIAL OF INTERVENTIONS FOR AUDITORY PROCESSING DISORDER: SPEECH-EVOKED CORTICAL AUDITORY EVOKED POTENTIALS AND BEHAVIOURAL MEASURES OF AUDITORY PROCESSING

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Background: Interventions for children with auditory processing disorder (APD) include environmental modification, and bottom-up (e.g. auditory training) and top-down (e.g. language therapy) treatment approaches. There are few controlled studies of the efficacy of these interventions. One recent study reported cortical auditory evoked potential (CAEP) and behavioural changes in auditory processing after a prolonged trial of personal FM. We evaluated several interventions using both CAEP and behavioural measures. Method: Participants were 60 children with suspected or confirmed APD aged 7-13 years (mean age 9.7 years, SD 1.4). Data was collected three times, with two baseline measurements separated by 10 days, and one follow-up assessment after the six-week intervention. Intervention consisted of either auditory/phonological awareness training (with/without personal FM) or language therapy (with/without FM). CAEPs evoked by the natural speech phoneme /da/ were recorded in quiet and in noise at Cz and Fz. Behavioural measures included performance on auditory processing, attention, reading, and phonological awareness tasks. Results: All interventions produced some significant changes in behavioural outcomes that were not present in the control group. Noise had a significant impact on CAEP latencies and amplitudes. There were significant and systematic changes in CAEPs across the three test occasions, and hence it was not possible to determine whether there was a therapy effect on CAEPs.
Discussion: It was possible to demonstrate positive effects of the interventions using several behavioural measures that were stable in the control group. Changes in CAEPs observed here across test occasions have been noted elsewhere (Smart, Purdy, Kelly, submitted). In both studies, children underwent extensive testing using a range of auditory stimuli. The results are consistent with published evidence for cortical changes after short-term auditory training or enriched auditory experience and Sheehan et al.'s (2005) report that exposure to repeated instances of a speech sound during ERP recording is sufficient to produce CAEP changes.

S35

AN INVESTIGATION OF AUDITORY MEMORY FOR TONAL AND NONWORD STIMULI IN ADOLESCENTS WITH WILLIAMS SYNDROME

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Background: Williams syndrome (WS) is a neurodevelopmental disorder resulting from a microdeletion on chromosome 7q11.23. Current research suggests that there is a marked strength in auditory processing in WS. This study investigated N100 and P300 ERP responses to tonal and nonword stimuli using two-deviant oddball paradigms. This paradigm presents both a target (low probability) and a distractor (low probability) stimulus, allowing for a distinction between the P3a (automatic orienting mechanism) and P3b responses (memory refreshing mechanism). An investigation of N100 and P300 responses to auditory stimuli in WS, in conjunction with behavioral speech perception testing allowed for a further differentiation of automatic orienting responses from auditory memory mechanisms in school-age participants with WS.

Methods: 8 participants with WS ranging in age from 13;00-21;11 and 8 age- and gender-matched controls completed a hearing evaluation, Kaufman Brief Intelligence Test-2, the Comprehensive Test of Phonological Processing, a nonword repetition task (based on Thorn, Frankish, and Gathercole, 2000 stimuli), and a two-deviant oddball paradigm for each tonal and nonword conditions. Multiple multivariate analyses of variances (MANOVAs) were performed on tonal and nonword stimuli for amplitude and latency of responses at electrodes Cz, Fz, and Pz by group.

Results: The N100 response for tonal stimuli was larger in amplitude in WS, providing support for increased orienting responses in WS. Furthermore, the P3a response for tonal and nonword stimuli showed decreased latency and increased amplitude in WS. There was an interaction between P3b responses for tones and nonword stimuli with WS having diminished responses for tonal stimuli and increased response for nonword stimuli in WS when compared with the control group.

Conclusion: Differences in auditory processing in WS are characterized by an increased orienting response to changes in tonal and nonword stimuli. However, this cannot be attributed to stronger auditory memory for tones, as P3b responses are diminished. The preservation of auditory memory for nonword stimuli suggests that WS benefit from low-frequency, segmental cues not provided in tonal stimuli.

EVALUATION OF SPEECH PROCESSING IN NOISE AND FM BENEFIT IN CHILDREN WITH AUDITORY PROCESSING DISORDER USING CORTICAL EVOKED POTENTIALS AND BEHAVIOURAL MEASURES

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Background: Auditory Processing Disorder (APD) is complex and the expression of APD in individuals is variable. As a result, a test battery approach to diagnosis is usually recommended. Due to this variability and the co-morbidity with other disorders (reading disorder, ADHD, etc.) objective tests of auditory processing would enhance current clinical test batteries. The use of objective tests to verify auditory difficulties such as poor speech perception in noise may assist clinicians in evaluating the benefit of treatment options, without the influence of test learning effects or participant characteristics such as motivation.
Method: We recorded speech-evoked cortical auditory evoked potentials (CAEPs) in quiet and in noise, auditory brainstem responses, and transient evoked otoacoustic emissions of 28 children diagnosed with APD before and after a 5-month trial period with a personal FM system. All children received a comprehensive audiological evaluation and were diagnosed with APD using several low-language tests of auditory processing (Frequency Pattern Test, Dichotic Digits Test, Gaps In Noise test, Compressed and Reverberated Words, Masking Level Difference test). The initial electrophysiological test results from the children with APD (n=28) were compared to an age-matched control group (n=34) who were tested on one occasion only.
Results: ABR and OAE results did not differ between APD and control groups, but CAEPs showed significant group differences. Noise increased CAEP P1 and N2 latencies and reduced N2 amplitudes. The impact of noise on CAEP latencies and amplitudes was significantly reduced when participants wore the FM. In the APD group, CAEP N2 latencies and amplitudes changed significantly across visits; changes occurred across the baseline and the FM trial period.
Discussion: CAEP results provide objective evidence for FM benefit. Changes in the CAEP waveform with repeated testing, prior to and after the FM trial indicate that further research is needed before CAEPs can be used as a reliable objective measure of treatment benefit.

TEST-RETEST RELIABILITY OF SPEECH-EVOKED CORTICAL AUDITORY EVOKED POTENTIALS IN QUIET AND IN NOISE AND CORRELATIONS WITH BEHAVIOURAL MEASURES IN CHILDREN WITH AUDITORY PROCESSING DISORDER

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Background: There is considerable interest in the use of objective electrophysiological measures for diagnosis of auditory processing disorder (APD) in children, but clinicians still generally rely on behavioural information for APD diagnosis. The reliability of electrophysiological measures such as obligatory cortical auditory evoked potentials (CAEP) has not been well established in children and the relationship between CAEPs and more conventional behavioural measures of auditory processing has not been widely explored.
Method: Participants were school aged children (7-13 years) with suspected (N=90) or confirmed (N=29) APD tested in two separate studies using speech-evoked CAEPs in quiet and noise recorded at Cz and Fz, and behavioural measures including the frequency pattern test, dichotic listening, masking level differences, random gap detection, and speech perception in noise. CAEPs were measured twice during the baseline period, prior to the children participating in an APD intervention study.
Results: Noise caused significant CAEP amplitude reductions and latency prolongation. CAEPs differed significantly between children with APD and a control group who were tested on one occasion only. CAEP latencies and amplitudes changed significantly between test and retest. There were some correlations between CAEP and behavioural measures; these were not consistent across electrode sites.
Discussion: There were significant differences in CAEPs between children with APD and a control group, indicating that CAEPs are sensitive to the effects of central auditory dysfunction. Participants underwent extensive testing during the baseline period that required 2-3 visits lasting approximately two hours. Repeated exposure to auditory stimuli during this time may have influenced CAEP findings. More information is needed on the reliability of CAEPs over time and with repeated testing in order to establish the appropriateness of these measures for diagnosis of APD and objective verification of the effects of treatment.

MULTISCALE MODELING AND ANALYSIS OF ATTENTION CORRELATES IN AUDITORY EVOKED POTENTIALS AND ITS APPLICATION

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The neurodynamics of the brain function covers spatio-temporal scales from the level of synaptic activity to the level of surface electroencephalographic correlates. A variety of multiscale computational methods have been developed in different scientific disciplines with a large impact in the modeling and analysis of the brain dynamics, e.g., to disclose multiscale phenomena underlying the electroencephalogram and event related response (ERP) generation or to improve the noninvasive neurodiagnostics and therapy in audiology using electroencephalographic methods.

This talk I will focus on two problems in auditory processing and perception using a multiscale model of the N1-P2 complex in auditory ERPs: (a) the modeling and analysis of attention correlates in the tinnitus decompensation; (b) the objective detection of the uncomfortable loudness level by regulatory effects of attention due to habituation.

The stimulations and prediction done by the presented multiscale model are compared to experimental data obtained in a variety of studies. In particular, three different studies where conducted for study (a) with 41, 29, and 6 patients as well as 10 control subjects. Here a time--scale analysis in all the studies resembled well the model predictions and allowed for an objective quantification of the tinnitus decompensation. In study (b) 20 subjects entered the study. Here is was possible to match the perceived loudness (measured by a subjective scale) to objective habituation measures in ERPs.

Both experimental studies showed a large qualitative correlation to the simulated data using the computational multiscale model.

It is concluded that computational multiscale modeling and analysis of attention in auditory processing and perception may provide a deeper understanding of the neurophysics and neurophysiology of the tinnitus decompensation and attention regulation by auditory habituation. We also conclude that the proposed analysis framework allows for an objective quantification of the tinnitus decompensation and might also allow for the objective detection of UCL correlates.

P300 LATENCY AND REACTION TIME IN CI RECIPIENTS DURING SOUND DISCRIMINATION IN NOISE

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Abstract: CAEP recordings from CI recipients as well as normal hearing subjects (NH) show an increase of the P300 latency with decreasing signal to noise ratio (SNR) which might reflect increasing discrimination effort. To investigate if the P300 may be a useful objective measure of this parameter, we compared the P300 latency to the reaction time, a parameter which is accepted as an indicator of hearing effort. CAEPs were recorded from adult CI patients and NH listeners during presentation (oddball paradigm) of speech sounds masked by white noise at various SNRs. Reaction time was calculated from mouse clicks in response to the deviant stimuli. For NH listeners, masking noise consistently induced an increase of the latency of the P300 at SNRs where subjective discrimination was still unambiguous (e.g., + 45 ms ± 3 ms (mean ± SEM) at SNR = -6 dB). Surprisingly, the simultaneously measured reaction time was not prolonged down to SNR=- 6 dB. Further decrease of the SNR induced increase of both the P300 latency and the reaction time. For CI patients, the results were comparable although shifted to higher SNRs, with higher interindividual variation, and with a lower correlation between the reaction time and the P300 latency. The results suggest that for NH as well as CI listeners, the P300 latency is a reliable measure for hearing effort during sound discrimination in noise, with higher sensitivity at moderate SNRs and lower variability as compared to the reaction time. Thus, it may be a useful indicator of hearing effort, e.g. in the optimization of speech processor strategies.
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A CHIRP STIMULUS IS WELL SUITED FOR NEWBORN HEARING SCREENING

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As an attempt to compensate for the delay in the normal human cochlea, a chirp stimulus has been constructed from estimates of the temporal contribution from different frequency bands to the normal click-ABR at 60 dB nHL. The chirp is constructed with an amplitude spectrum similar to that of a standard 100 μs click. Therefore, the psychoacoustic thresholds of the two stimuli are identical in normal-hearing adults.
The amplitudes of chirp-ABRs and chirp-ASSRs are 1.5 - 2 times larger than the amplitudes of the corresponding click-responses in normal-hearing adults. However, this advantage of the chirp is largest at lower stimulus levels, and probably disappears at higher levels.
For newborn hearing screening, ASSRs can be detected by an automatic detection algorithm, with an estimated sensitivity of 99.9% and a measured specificity of 96.1% for 1'st stage screening, and 99.5% for 2'nd stage screening. Clinical findings in thousands of newborns demonstrate, that in response to a chirp at 35 dB nHL the median detection time is 24 s, but in response to a click at 40 dB nHL, the detection time is 46 s. The cochlear model used to construct the chirp, is based on ABR-recordings from adults. It can therefore be questioned if the chirp is appropriate for the compensation of the cochlea delay in newborns. However, the clinical findings demonstrate that the chirp is significantly more efficient than the click also in newborns. Thus, it is found that the chirp has the same psychoacoustic threshold as the click (in normal-hearing adults) and can therefore be calibrated using existing click-calibration procedures. At lower stimulus levels, the chirp generates significantly larger response amplitudes than those generated by the click. The chirp is therefore especially appropriate for newborn hearing screening, and, compared to the click, it reduces the testing time by more than 50%.

AGE DEPENDENT PASS-FAIL CRITERIA FOR OTOACOUSTIC EMISSIONS IN NEONATAL HEARING SCREENING

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The problem with otoacoustic emission (OAE) screening for neonatal hearing loss is that the OAEs are small at birth and increase in amplitude over the first few days of life. The pressure for early discharge from maternity units is such that babies have to be tested at less than 24 hours old. This leads to a high false alarm rate (diagnosing well babies as hearing impaired) with subsequent overloading of the diagnostic clinic and worry to the parents. We therefore used our database of over 22,000 babies to examine whether age-dependant criteria could be developed which would decrease the false alarm rate. We first confirmed that all of the parameters used for pass-fail criteria increase or improve with age. Using ROC curves the optimum criteria were calculated for age groups 3 hours apart. The results appeared bizarre as very low, often negative, values were obtained as the best criteria value for parameters such as signal-to-noise ratio. In order to verify these findings obtained from the Wessex database we approached the MRC screening programme and requested the use of their database. Very similar results were obtained from the MRC database and optimal values, obtained from the Wessex database, made significant reductions in the false alarm rate when applied to the MRC database. These results will be discussed, the parameters for the pass-fail criteria given and an approach that will produce the best results for any given clinic will be presented.

GABOR FRAME DECOMPOSITIONS FOR THE ULTRAFAST DETECTION OF CHIRP EVOKED AUDITORY BRAINSTEM RESPONSES

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In this work we propose for the first time Gabor frame operators as efficient feature extraction technique for ABR single sweeps that can be processed using a novelty detection paradigm. We use this decomposition technique to derive the Gabor frame phase stability (GFPS) of ABRs sweeps.
Chirp and click evoked ABRs were obtained from 20 volunteers (threshold<15 dB(HL); 24.45±3.80 years; 13/7 female/male) with no history of hearing problems. In each experiment 2 types of electrodes passive (PE) and active (AE) were used (Impedances remained <5KΩ). First AE were attached and ABRs were obtained using clicks at intensity levels of 40, 30, 20 dB(SPL) and the spontaneous activity (using no stimuli). Later the chirps were presented for the same intensity levels. Then, the electrodes were changed for PE and the same stimulation procedure was applied. Each condition had 2000 sweeps free from amplitude artefacts (15 µVolts).
We show that the GFPS of chirp evoked ABRs provide a stable discrimination of the spontaneous activity from stimulations above the hearing threshold with a minimum number of sweeps, especially for the chirp stimulations. This is the first study directed to an ultrafast single sweep analysis of chirp evoked ABRs.
It is concluded that the GFPS represents a robust feature of ABRs which allows for an ultrafast discrimination of the spontaneous activity from stimulation intensities above the hearing threshold, especially for chirp stimulations, and might be used in expert based diagnostic procedures directly or for the ultra-fast detection of the hearing threshold by cojoint systems with a computational decision making stage according to the novelty detection paradigm. We conclude that our study reinforces the use of chirp stimulations for the fast hearing threshold detection.

LONGITUDINAL STUDY OF AUDIOLOGICAL EXAMINATIONS IN CHILDREN WHO WERE EXAMINED BY PROCEDURE OF PRENATAL HEARING SCREENING

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The ability of auditory perception starts its development in intrauterine life, which continues to the age of 11, when CNS myelinisation process is completed Early detection and diagnostics of the degree of auditory perception development enables early speech and language habilitation, and points to necessity of auditory perception examinations in prenatal period followed by early postnatal examinations.

Research aim was examination of auditory perception development in children who were examined by procedure of Prenatal hearing screening (PHS).

Research sample comprised N=62 children at the age from 3.5 to 4.5 years, who were examined by PHS, and was divided into two groups: 1.) Control group consisted of children from low risk pregnancies (C=30) and 2.) Experimental group consisted of children from high risk pregnancies (E=32).

Method of examination in both groups of children included: 1. application of PHS procedure in prenatal period; 2. audiological examinations (transient evoked otoacoustic emissions - TEOAE, tympanometry, pure tone audiometry) in children at the age of 3,5 - 4,5 years who were examined by PHS; 3. comparison of PHS results with obtained audiological findings.

Results of this longitudinal study showed that auditory perception disorders were registered in 4.8% of children in whole sample (6.7% in C group and 3.1% in E group). Comparative analysis of PHS results and TEOAE, tympanometry and PTA findings showed that all children with negative audiological findings had index of relative Pi change higher then 11.9%.

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INTERNATIONALLY COORDINATED NEWBORN HEARING SCREENING AND FOLLOW-UP PROGRAMS

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The knowledge and expertise of numerous experts from varying fields (at the clinical and the research level) will contribute to draw the internationally designed recommendations on NHS. The principles of all programs are based on their justification, assessment of screening performance and the prevalence and impact of newborn diseases and disorders. The recommendations for the national NHS programs have to consider the information on screening systems currently used in each country, current screening methods, result interpretation, personnel/equipment requirements for newborn hearing screening, system performance and future technological options. Special attention must be drawn to screening programs for the developing countries and the development of protocols for rural/community based screening.

Screening from an economic viewpoint is influenced by measures of benefit, necessity of efficacy, economic parameters, global effect on local family unit, local community, region, nation, world. The ethics of screening and communicating with parents is very important component of the program. It includes parent perspectives, their empathetic understanding, involvements into the screening and diagnostic process. All NHS programs have to be followed by paediatrician's assessment and preferably by newborn metabolic and genetic screening

Integrated health care and data systems have valuable impact on screening success (integrated health care and its impact on the newborn, the family, and society; models of integrated care; data management for newborn screening systems; limitations of current data systems). The follow-up strategies must be considered as an integral part of each NHS program. To improve the effectiveness of the follow-up the development of standardized algorithms for follow-up testing and monitoring of follow up results is recommended.

The final stage of screening is early intervention. Only screening with consequences makes sense.

These recommendations will provide the entire collection of screening programs routinely delivered to newborns and will prescribe direction for future endeavors in this area.

RESULTS OF POLISH PROGRAM OF UNIVERSAL HEARING SCREENING CONDUCTED BY GREAT ORCHESTRA OF CHRISTMAS CHARITY IN 2002-2008

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The number of children screened till November of 2008 exceeded 2 000 000. This gives the coverage obtained by the screening of newborns in the whole country about 96%. The percentage of children with positive result of screening with recommendation for audiological observation is 8,7%. It includes positive screening (4%) and risk factors (3,8%), and with no screening (1,5%). Almost 50% of children with the recommendation attended audiological diagnostics, 63% of them got specialized help before 3rd month of life. The motivation of parents in participating in the audiological investigation is dependent on results of the screening. Corresponding percentages are as follows: presence of risk factors (including positive OAE test) 57%, positive OAE test only 45%, no screening 33%. Over 80% of children with positive audiological diagnostics were confirmed with objective methods. From these groups, the 55% had no risk factor. This proves necessity of keeping full coverage by screening with OAE or other objective methods.

HEARING SENSITIVITY AND AUDITORY FUNCTION IN CHROMOSOME 7 DISORDERS

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Background: Hearing loss is pervasive and progressive in individuals with Williams syndrome (WS). Deletion at chromosome 7q11.23 results in WS. The WS region is known to also undergo duplication or inversion, neither of which results in WS. The rearrangements at 7q11.23 present a unique opportunity to study possible gene(s) contributing to auditory sensitivity and function.
Aims: Preliminary studies have suggested that one of the genes in the WS deletion, elastin (ELN), might be implicated in the auditory dysfunction (Gothelf et al., 2006; Marler et al., 2005). We studied and compared auditory function in individuals with WS (classic 7q11.23 deletion), nonsyndromic Supravalvar Aortic Stenosis (SVAS, ELN deletion or point mutation), small deletions in the 7q11.23 region (including ELN deletion), and duplication of the WS deletion regions (3 ELN alleles).
Method: We used standard audiometric screening and diagnostic tools, otoscopy, tympanometry, air-conduction (bone conduction when available) behavioral testing and distortion product otoacoustic emissions (DPOAEs) to measure hearing sensitivity and outer hair cell function. We worked with individuals with WS (n=87), SVAS (n=9), small deletions (n=6), and duplications (n=3).
Results: Statistical and descriptive analyses show individuals with WS have mild, mild-to-moderate, or moderate-to-severe hearing loss. Behavioral results were corroborated by DPOAE testing. Seven/9 individuals with SVAS had normal behavioral hearing and 4/9 had significantly depressed DPOAEs. Four/6 individuals with small deletions had normal behavioral hearing and 5/6 had significantly depressed DPOAEs. Finally, Two/3 individuals with duplications had normal behavioral hearing and 2/3 had DPOAEs within normal limits.
Conclusions: Elastic fiber structure in the middle-ear system will be presented, and possible contributions to DPOAE results will be discussed. To summarize the data, ELN disruption to retrograde transmission of DPOAEs through the middle-ear system does not explain hearing loss in individuals with WS.

FIVE CHIRP STIMULI DESIGNED FROM DIFFERENT VERSIONS OF A DERIVED-BAND LATENCY MODEL

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ABR stimuli for hearing screening and frequency specific hearing threshold assessment have previously been developed based on an upward chirp. This chirp attempts to compensate for the cochlear traveling delay, and therefore provides a more synchronous excitation of the cochlea than obtained by a more traditional stimulus - for instance a click.
The chirp has been designed from a model of the cochlear delay based on derived-band ABR-latencies recorded in normal-hearing subjects. To investigate the adequacy of this delay model an experimental study was carried out using five chirp stimuli constructed from different values of the model parameters. The five chirps - numbered 1-5 according to increasing model delay - and a reference click were presented to 34 normal-hearing subjects at 30 and 50 dB nHL. From each ABR the latency and amplitude of wave V(?) are measured. As expected, the value of both parameters of the click-ABRs differ from those of the chirp-ABRs: (1) at each stimulus level, the latency of the chirp-ABRs is shorter than the latency of the click-ABRs; (2) the latency of the chirp-ABRs decreases with increasing delay of the underlying latency model; (3) at each stimulus level the amplitude of the chirp-ABRs is significantly higher than the amplitude of the click-ABRs; and (4) the amplitudes of the ABRs to chirp 3 and 4 are significantly larger than the amplitudes of the three other chirp-ABRs (chirp 1, 2 and 5). The amplitude of the ABRs to chirp 4 is found to be slightly larger than the amplitude of the ABRs to chirp 3.
From these results it may be concluded that minor changes of the parameter values, relative to those previously used for the construction of the chirp, could further enhance the efficiency of the chirp for the recording of broad-band ABRs in normal-hearing adults.

CHARACTERISTICS OF P50 ELICITED BY SPEECH TOKENS

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P50 is an auditory evoked potential thought to assess sensory gating, or the ability of the brain to suppress responses to irrelevant signals. P50 is used to detect deficits in sensory gating associated with specific neurological conditions, such as schizophrenia and cognitive impairments. Clicks and tone bursts are typically used to elicit the P50, and the variability among subjects is large. The purpose of the current study is to further develop the P50 as a measure of sensory gating through the use of speech tokens, which are hypothesized to be more physiologically relevant and reliable than clicks and tone bursts. In this study, paired speech tokens (da) were presented with three inter-stimulus intervals (ISI of 400, 500, and 800 ms), and stimulus pairs were separated by 10 s. Stimuli were presented to each ear and responses were recorded over Cz, T3/5, and T4/6. Subjects were 12 young adults screened to have normal hearing (pure tone thresholds 250-8000 Hz <20 dB HL) and normal cognitive function. P50 was elicited from all participants in all conditions, and response amplitudes were larger than those noted in previous investigations using clicks and tone bursts. More robust P50 amplitudes were obtained over the vertex than over either hemisphere regardless of stimulus ear. The maximum suppression ratio occurred with an ISI of 400 ms, although differences in amplitude ratios across conditions did not reach statistical significance. No clear effects were noted for different hemispheric recording locations. In summary, speech tokens appear to have improved reliability for eliciting the P50.

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ENVELOPE AND SPECTRAL FREQUENCY-FOLLOWING RESPONSES TO NATURALLY PRODUCED VOWELS

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Speech-evoked frequency-following responses may be ideal for evaluating the peripheral encoding of speech sounds - especially for aided assessments, since modern hearing aids exhibit non-linear behavior designed to preferentially amplify speech. Several studies have shown that responses can be recorded to components in the vowel envelope (glottal pulse modulations) and spectrum (harmonics). Additionally, since harmonics are selectively enhanced by formants, responses to harmonics may provide information about the audibility of the formant structure of speech. This study used a sine-cosine Fourier analyzer to analyze both envelope and spectral responses to naturally produced vowels in adults with normal peripheral hearing sensitivity. Responses to the envelope ("envelope FFR") and spectrum ("spectral FFR") were obtained by adding and subtracting responses to stimuli presented in opposite polarities. Significant envelope FFRs were detected at the fundamental frequency for all subjects, with smaller responses at other low-frequency harmonics. Significant spectral FFRs were detected at harmonics near formant peaks (below 1500 Hz), and at frequencies corresponding to cochlear distortion products, but these were not significant for all subjects. These results indicate that both envelope and spectral FFRs can be recorded to naturally produced vowels, but that envelope FFRs to lower frequency components are most robust.

AUDIOLOGICAL PROFILE OF CHILDREN WITH COCHLEAR NERVE DEFICIENCY

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Background: Cochlear nerve deficiency (CND) is not a rare cause of congenital hearing loss. The fact that CND may or may not associated with inner ear malformation makes the audiological presentation variable. Objective: To present the audiological profile of a group of children with this disorder evidenced by high resolution MRI. Methods: 20 cases (37 ears), aged from 10 to 48 months, with both audiological and MRI data were involved in this retrospective study. In order to analyze the audiological data, they were divided into three groups depending on whether or not there was an associated inner ear abnormality. Group A (12 ears, 6 bilateral) were children with cochlear abnormality or both cochlear and vestibular abnormality; Group B (5 ears, 3 unilateral and 1 bilateral) were with vestibular abnormality only while Group C (20 ears, 8 bilaterally and 4 unilaterally) were with normal inner ears. Click ABR, cochlear microphonics (CMs) evoked by clicks with alternating polarity and distortion product otoacoustic emissions (DPOAEs) were analyzed. Results: In all these CND ears. 86.5% (32/37) were with absent click ABR at the maximum output (100 dB nHL) and 13.5% (5/37) only had not well-defined Wave V at high levels (greater than 80 dB nHL). DPOAEs/CMs: All the ears in Group A had absent DPOAE/CM. In Group B, 60% of the ears（3/5）were with absent DPOAE and/or CM whereas 40%（2/5）were presented with DPOAEs and/or CMs. 45%（9/20）in Group C were with absent DPOAE and/or CM and 55%（11/20）were presented with DPOAEs and/or CMs. Conclusion: Audiological profile of CND varies according to the associated inner ear abnormality. They can be presented with audiological presentation of cochlear loss and auditory neuropathy. MRI is needed for the differential diagnosis and further intervention of the hearing loss.

ABSTRACTS

POSTER PRESENTATIONS

P1

APPLICATION OF THE AUDITORY BRAINSTEM RESPONSE FOR SCALING IMPULSIVE AND CONTINUOUS NOISE

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The aim of the work was to test whether it is possible to scale the impulsive noise and continuous noise by equivalent wave V latency or thresholds in the auditory brainstem responses (ABRs). A forward masking paradigm was used in which a 4-kHz tone pip was to evoke the ABR. The tone pip was masked by the preceding 201-ms or 501-ms interval of click trains or band-pass noise. Effect of masking was measured for click/noise SPL varied in 10-dB steps. Masking click trains differed in number of clicks presented in a range from 50 clicks/s (Δt = 20ms) to 10 clicks/s (Δt = 100ms). Bands of continuous noise ranged in their center frequency from 250 Hz up to 4000 Hz. Results allowed for a comparison of masking effect of impulsive noise and that of continuous noise.

P2

THE USE OF 8 KHZ TONE-BURSTS TO EVOKE AUDITORY BRAINSTEM RESPONSES FOR THE PURPOSE OF OTOTOXIC MONITORING

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Background: Recording the auditory brainstem response evoked by high frequency (≥ 8 kHz) tone-bursts has been proposed as a method for monitoring ototoxic effects of medication in patients who cannot complete conventional high-frequency audiometry. However, earphones and stimulus parameters traditionally recommended for tone-burst ABR are not necessarily well suited for this purpose and may result in significant inaccuracies and false negative evaluations.
Aims: This study sought to document and analyze the effects of 8 kHz tone-bursts using a 2-0-2 envelope and generated by both ER-3A insert earphones and TDH headphones.
Methods: Electroacoustic spectral analysis was performed for high-frequency tone-bursts with various rise/fall times and both ER-3A and TDH transducers. The psychoacoustic thresholds to the tone-bursts were obtained from 10 subjects (20 ears) with sloping sensorineural hearing loss from 4-8 kHz.
Results: Using ER-3A earphones and 2-cycle rise times, the 8 kHz tone-burst is spectrally distorted as compared to those at .5-4 kHz and contains significant energy at lower frequencies. Significant underestimations were observed when comparing the electrophysiologic nHL thresholds using these tone-bursts to the 8 kHz HL psychoacoustic thresholds of subjects with sloping high-frequency sensorineural hearing loss.
Conclusions: Traditional techniques for recording tone-burst ABRs should not be extended to frequencies above 4 kHz without special attention to the choice of transducer and/or stimulus duration. Neglecting these factors can result in a stimulus not representative of the desired target frequency which may ultimately lead to threshold underestimation and a failed sensitivity to ototoxic change. Alternative techniques for recording high-frequency ABRs are recommended.

P3

AUDITORY EVOKED POTENTIALS STABILITY IN NORMAL INDIVIDUALS

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Background: Auditory Evoked Potentials (AEP) evaluate the central auditory nervous system, helping audiological diagnosis for being precise and objective. They are also indicated for monitoring therapeutic process and functional changes in the auditory nervous system after a stimulation period, such as neuronal plasticity. Hence, it is necessary to verify the stability of latency and amplitude parameters of AEP in individuals not submitted to speech-language rehabilitation, in order to confirm that, in subjects attending speech-language therapy, possible changes in AEP parameters are due to neuronal plasticity. Aim: To verify AEP latencies and amplitudes stability in normal adults. Methods: Audiological (pure tone audiometry, speech audiometry, and acoustic immittance measures) and electrophysiological (Brainstem Auditory Evoked Potential - BAEP, Mid-Latency Auditory Evoked Potential - MLAEP, and P300) evaluations and reevaluations were carried out with 49 normal subjects, 25 female and 24 male, with ages ranging from 18 to 40 years. Reevaluation was carried out three months after the first evaluation. The results were quantitatively analyzed using statistic tests. Results: No statistically significant differences were found between the results obtained in both evaluations for the parameters analyzed in BAEP (absolute latencies of waves I, III and V and interpeaks I-III, III-V and I-V), MLAEP (amplitude Na-Pa, latencies of waves Na and Pa), and P300 (latency of the P300 wave and N2-P3 amplitude). Conclusion: It was observed stability of the BAEP, MLAEP and P300 parameters in normal adults after a three-month period.

P4

BRAINSTEM AUDITORY EVOKED POTENTIAL WITH SPEECH STIMULUS IN CHILDREN WITH PHONOLOGICAL DISORDER

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Background: Phonological disorder is characterized by difficulties in one or more levels responsible for the phonological system development. The Brainstem Auditory Evoked Potential is an objective test that evaluates the auditory pathway integrity at the brainstem level and complements the basic audiological procedures for the diagnosis of auditory alterations. Given that the phonological development, as well as the development of other linguistic aspects, depends on the adequate functioning of the auditory system as a whole, it is important to know the functioning of the central auditory system at the brainstem region in children with phonological disorder. Aim: To characterize the findings of Brainstem Auditory Evoked Potentials with speech stimulus in children with phonological disorder. Methods: Thirty-six normal hearing children (20 with phonological disorder and 16 with typical development), with ages varying from seven to 11 years, participated on this study. The subjects were submitted to pure tone audiometry, speech audiometry, acoustic immittance measures, and Brainstem Auditory Evoked Potential (BAEP) with speech stimulus on the right ear. Results were statistically analyzed. Results: It was observed longer latency values for the components V, A, C and F of the BAEP with speech stimulus in children with phonological disorder, when compared to typically developing children. A statistically significant difference was found between groups for wave V latency, and a tendency towards difference for wave A latency, as well as for the complex VA area. Conclusion: Children with phonological disorder showed longer latencies at the BAEP with speech stimulus when compared to typically developing children, suggesting central auditory pathway alteration, which may compromise the adequate phonological development of this population.

P5

SPEECH-EVOKED ABR IN CHILDREN WITH AUDITORY PROCESSING DISORDER

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Background: Traditionally the auditory brainstem response (ABR) test has been used to diagnose retrocochlear disorders or for frequency specific testing to measure threshold sensitivity in infants. Recent publications have demonstrated it is possible to use a speech phoneme to elicit an ABR and frequency following response. It has been proposed that the speech-evoked ABR may be an effective test for the diagnosis of learning/auditory disorders in children, when there is a timing disorder in the brainstem (Johnson et al., 2007; Banai et al., 2005; Johnson et al., 2005). Recent reports of the diagnostic utility of the speech-evoked ABR indicate that the test warrants further exploration in other groups of children with auditory processing disorder (APD).
Method: This study examined the speech evoked ABR data from 29 children aged 7,3 to 12,9 years (mean 9.84, SD 1.80) with confirmed APD (N=23 males, N=6 females). A control group of 28 children with no history of APD, matched for age, was used for comparison purposes. All children had hearing thresholds within normal limits, normal middle ear status, present transient evoked otoacoustic emissions, and normal nonverbal intelligence. The ABR was recorded to a high-level click and a natural speech phoneme.
Results: Robust speech-evoked ABRs were recorded, consisting of an onset response and then a series of smaller peaks consistent with phase-locked activity, similar to previous reports. A repeated measures analysis of variance found no statistically significant group differences ($p > 0.05$) for any of the latency or relative amplitude measures for these peaks.
Discussion: The results are not consistent with previous reports of abnormal speech-evoked ABRs in children with learning/auditory difficulties. This may be due to stimulus or population differences.

P6

BRAINSTEM AND MIDDLE-LATENCY AUDITORY EVOKED POTENTIALS IN PATIENTS WITH RIGHT HEMISPHERE ISCHEMIC LESION

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Background: The ischemic cerebral stroke (ICS) is characterized by the interruption of blood supply to the brain, causing cellular lesion and alterations of neurological functions, which can vary enormously. Therefore, the early identification of changes in auditory pathways that might impair the quality of life of individuals with ICS is important. Aims: To characterize the results of Brainstem Auditory Evoked Potentials (BAEP) and Middle-Latency Auditory Evoked Potentials (MLAEP) of individuals with right hemisphere ischemic lesion. Methods: Anamnesis, a screening protocol, pure tone audiometry, speech audiometry, acoustic immittance measures, BAEP and MLAEP were carried out with 17 subjects with right hemisphere ischemic lesion (mean age 48.71 years, Research Group) and 25 normal subjects (mean age 34.48 years, Control Group). All individuals were right-handed, had no auditory complaints and normal auditory thresholds. Results: In the analysis of qualitative data, a statistically significant difference was found between groups for BAEP and MLAEP results. The Research Group had significantly more occurrences of alterations: the most frequent alteration in the BAEP was the low brainstem type, while in the MLAEP, both type (ear and electrode effects occurring concomitantly) was most frequently found. Quantitative data analysis showed, for the BAEP, a significant difference between groups regarding the latencies of the waves III and V and interpeaks I-III and I-V. For the MLAEP, there was a significant difference between groups regarding the latency of the Na wave at the position C3/A1. Conclusions: Right-handed subjects with ICS presented alterations of the auditory pathway in the brainstem and subcortical/cortical regions that might be related to a deficit not identified by the patient, therefore possibly related to an auditory hemineglect. Further studies are necessary to evaluate the central auditory pathways of these individuals for a better characterization of their electrophysiological findings.

P7

THE ACOUSTIC-CHANGE COMPLEX ELICITED TO SPEECH STIMULI IN FOUR-MONTH-OLD INFANTS AND ADULTS WITH NORMAL HEARING.

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Background: When the P1-N1-P2-N2 complex is elicited by acoustic changes in speech stimuli; the resultant waveform, the acoustic change complex (ACC), contains multiple overlapping P1-N1-P2-N2 complexes; discrimination of a change is reflected in the presence and characteristics of the response to the second stimulus. The ACC has not yet been recorded in infants (although its constituent responses, especially P1 have been investigated) but may yield a more robust and consistent response than the other responses (e.g., mismatch negativity). Aim: To determine whether the ACC can be used to assess discrimination ability in infants and adults for Hindi contrasts. Methods: Infants (four months of age) and adults with normal hearing were tested. Stimuli were made from Hindi speech tokens. For adults, the ACC was recorded using three experimental S1S2 stimuli (/dada/, /daba/ & /daDa/; 564 ms in duration; 2200 ms interstimulus interval) & two control stimuli, S1 plus a quiet period (/da_quiet/ and /ba_quiet/), each presented in blocks of 300 stimuli. Infants were tested using only /daba/, /dada/ and /da_quiet/. The stimuli were presented at 75 dB SPL in the sound field. The peak-to-peak amplitude of the N1-P2 component to S1 and S2 stimuli were measured. For S1S2 stimuli, the amplitude of N1-P2 component to S2 was calculated as a percentage of the amplitude of N1-P2 to S1. Results: The ACC in adults was largest for /daba/, smaller for /dada/ and smallest when the S1 and S2 were the same (i.e., /dada/). The largest difference in the ACC to /daba/ is not explained by inherent differences in the obligatory responses. An ACC was recorded in infants. Conclusions: Results for adults indicate that the ACC can be elicited to Hindi contrasts and reflect expected discrimination patterns. Preliminary data indicate that the ACC can be elicited in infants; however, further investigation is needed to assess their discrimination patterns.

P8

MATURATION OF BONE-CONDUCTION AUDITORY STEADY-STATE RESPONSE THRESHOLDS IN OCCLUDED AND UNOCCLUDED EARS IN INFANTS WITH NORMAL HEARING.

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Background: Unlike adults who show improvement in low-frequency bone-conduction (BC) thresholds when ears are occluded [i.e., occlusion effect (OE)], young infants do not appear to show this phenomenon when BC auditory steady-state (ASSR) thresholds are compared for occluded and unoccluded ears. The OE in adults is explained by the transmission of vibratory energy via the osseotympanic pathway. In the unoccluded adult ear, this energy is lost through the open ear canal; in the occluded ear, this energy results in better low frequency thresholds. Little is known about the time course of maturation of the OE or the factors that contribute to its absence in young infants. Aim: To determine at which age BC thresholds improve when the ear is occluded and to investigate the mechano-acoustical properties that underlie this phenomenon. Methods: (i) An adult group was tested to confirm that the SPL in the ear canal for adults with normal hearing increases at 500 & 1000 Hz (and not at 2000 Hz) when the ear is occluded and that their BC behavioural thresholds improve at 500 and 1000 Hz (and not at 2000 Hz), as expected. (ii) infants of different ages are assessed in a cross-sectional design (longitudinally when possible); BC ASSR thresholds & SPL measures for unoccluded & occluded ears are obtained & compared to wideband reflectance measures (i.e., estimate of sound transmitted through the middle ear) for each infant. Results: (i) Adult results showed that SPL measurements increased linearly with intensity above the noise floor (30-50 dB HL) at all frequencies, and that significant increases in SPL in the occluded ear canal occurred only for frequencies that showed an OE (i.e., 500 & 1000 Hz). (ii) Preliminary results indicate that infants show an increase in SPL at 500 & 1000 Hz and not at 2000 Hz by 12 months of age, similar to adults. Conclusion: The osseotympanic pathway appears to contribute to BC hearing by 12 months of age.

P9

MULTIPLE-ASSR THRESHOLDS TO BONE CONDUCTION STIMULI IN ADULTS WITH SENSORINEURAL HEARING LOSS

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ASSRs to multiple air-conduction (AC) stimuli modulated at ~80Hz have been shown to provide reasonable estimates of the behavioural audiogram. To distinguish the type of hearing loss (i.e., conductive/sensorineural/mixed), bone-conduction (BC) threshold data are necessary. There are few published BC-ASSR data, especially for individuals with hearing loss. In the current study, we determined pure-tone behavioural and multiple-ASSR thresholds to BC stimuli in 45 adults (mean age=50 years; 35 with SNHL, 10 with normal hearing). The multiple (0.5-4 kHz) ASSR stimuli were modulated between 77-101Hz, and varied in intensity from 0 to 50 dBHL using 10-dB steps. Stimuli were presented using a B71 bone oscillator held on the temporal bone by an elastic band while the participants slept. Results show that multiple-ASSR thresholds were, on average (±1SD), 16±14, 10±11, 9±10 and 5±8 dB above behavioural thresholds for 0.5, 1, 2, and 4 kHz, respectively, with correlations of .64, .81, .84. and .94. The ASSR-behavioural difference scores were significantly ($p<.01$) larger for 500Hz and significantly smaller for 4kHz compared to 1 and 2 kHz. Across all frequencies, the BC-ASSR correctly classified 87% of thresholds as "normal" or "elevated" (94% correct for 2 and 4 kHz). Conclusions: The threshold-difference scores and correlations in SNHL are similar to those in normal-listeners with simulated SNHL (Cuthbert & Stapells, IERASG 2009), and for AC-ASSR in SNHL (e.g.., Dimitrijevic et al., 2002; Herdman & Stapells, 2003). Except at 500 Hz, the BC-ASSR provides a reasonably good estimate of BC-behavioural threshold. The poorer results at 500Hz could be due to a number of reasons, including: a limited range of hearing loss, occurrence of non-auditory responses, and/or issues with ASSR for 500 Hz. [Work supported by NSERC and CIHR.].

P10

MULTIPLE-ASSR (80 HZ) BONE-CONDUCTION THRESHOLDS IN ADULTS WITH NORMAL HEARING AND MASKER-SIMULATED HEARING LOSS

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Auditory steady-state responses (ASSRs) are currently being used by many for threshold estimation in young infants. Complete assessment of infants with elevated thresholds requires bone-conduction (BC) measures. However, few data exist demonstrating the relationship between BC-ASSR thresholds and elevated behavioural thresholds. [See also: Ishida & Stapells, IERASG, 2009.] The current study compared behavioural bone-conduction thresholds to multiple-ASSR BC thresholds, using systematic AC masker-simulated threshold elevations. Behavioural and ASSR thresholds for 4 masking conditions (no-masker, and 50-, 60-, and 70-dB SPL AC pink-noise maskers) were obtained from each of 16 normal adults (mean age = 27 years). Multiple BC stimuli (500-4000 Hz modulated 77-101 Hz) were presented to a B-71 bone-oscillator placed on the temporal bone. BC stimuli ranged from 60 to -10 dB HL for behavioural testing (single frequency); 50 to -10 dB HL for ASSR testing (multiple frequencies). Insert earphones (for masking noise) were inserted in both ears for all conditions. RESULTS: Behavioural BC thresholds were elevated, on average, 19, 27 and 36 dB for the 50, 60, and 70 dB SPL maskers, respectively. BC-ASSR thresholds were also elevated; however, there was a significantly larger difference for the no-masker condition (ASSR-minus-behavioural difference score: 16.2±11.0 dB) compared to the 70 dB SPL masker condition (11.4±8.1dB). Additionally, there was a significantly larger threshold difference score for 500 Hz (20.9±11.2 dB) compared to 1000 (12.6±8.5 dB), 2000 (10.1±7.4) or 4000 Hz (9.5± 7.3 dB). Importantly, correlations between BC behavioural and BC ASSR thresholds were acceptably high, with the possible exception of 500 Hz (500 Hz: r = .75; 1000 Hz: r = .85; 2000 Hz: r = .88; 4000 Hz: r = .88). These results suggest that BC multiple-ASSR may provide a reasonably accurate estimation of behavioural BC thresholds, especially for 1000 to 4000 Hz. [Work supported by NSERC-Canada.].

P11

THE BRITISH COLUMBIA CHILDREN'S HOSPITAL TONE-EVOKED ABR PROTOCOL: HOW LONG DO INFANTS SLEEP, AND HOW MUCH INFORMATION CAN BE OBTAINED IN ONE APPOINTMENT?

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The air (AC) and bone (BC) conduction tone-evoked auditory brainstem response (ABR) is the gold-standard method to assess hearing in young infants and difficult-to-test children. Although many early hearing programs report good success with tone-ABR protocols, there is little published providing quantitative information. Furthermore, there are often questions from clinicians considering the implementation of a tone-evoked ABR protocol as to how much testing can be completed within a single appointment. The test sequence of the tone-ABR protocol at BCCH emphasizes efficiency and obtaining information in a prioritized fashion (BCEHP Diagnostic Audiology Protocol, 2008). In the current study, we carried out a chart review of all the ABR assessments during a 20 month period at BCCH, obtaining results for 193 assessments: 116 sedated (median age = 23 months) and 77 non-sedated (median age = 5 months). 48% of the infants had elevated thresholds. RESULTS: The average test time (i.e., the amount of recording time during which an infant slept) for sedated assessments was 65.3 minutes (80% ≥ 33.1'); non-sedated assessments averaged 50.9 minutes (80% ≥ 25.4'). We also determined the number of "measures" (e.g., thresholds) obtained during each assessment. The maximum number of measures possible for two ears was 14 (AC threshold at 500, 1000, 2000, 4000 Hz; when indicated, BC at 500, 2000 Hz and/or AC clicks). The average number of measures obtained for sedated assessments was 7.4 (80% ≥ 6); non-sedated averaged 6.5 measures (80% ≥ 5). In addition, we also obtained immittance results in 75.4% and otoacoustic emissions in 53.8% of assessments. These results clearly show that even in non-sedated infants, a reasonably long test time is available for most infants, and that, with the use of an efficient tone-ABR protocol, we are able to obtain a substantial amount of information about hearing within one appointment.

P12

WHICH IS FASTER TO ESTABLISH "NORMAL" VERSUS "ELEVATED" THRESHOLDS IN INFANTS AND YOUNG CHILDREN: TONE-EVOKED ABR OR MULTIPLE ASSR?

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Abstract: Multiple auditory steady-state responses (ASSRs) to stimuli modulated at ~80 Hz for the assessment of infants has an advantage over the tone-evoked Auditory Brainstem Response (ABR) in that it allows one to test four frequencies in both ears simultaneously. This feature of the ASSR presumably allows for a faster determination of normal hearing, which would be an advantage in a population where the majority of infants have normal hearing, such as those referred from a universal newborn hearing screening program. In the current study, we tested at screening intensities (Van Maanen & Stapells, IERASG 2009; Janssen, Stapells & Usher, IERASG 2009) and determined the length of time required to establish normal hearing in both ears of 61 infants (median age = 23 months) using the multiple-ASSR (500, 1000, 2000 & 4000 Hz) versus the tone-evoked ABR (500, 2000 & 4000 Hz). Results show that ASSR was significantly faster to establish normal for four frequencies (9.1+/-5.3 minutes) than the tone-ABR for three frequencies (12.3+/-1.9 minutes, $p<.01$). When hearing is not normal, however, an efficient test should also be quick to indicate "no response". We therefore assessed time to indicate "no response" in a group of 29 infants (median age = 26 months) with hearing loss. The no-response results show that ASSR was slightly but significantly faster to establish "elevated" for four frequencies (14.9+/-2.1 minutes) than the tone-ABR for three frequencies (15.5+/-2.6 minutes, $p<.05$). In conclusion, multiple-ASSR identifies hearing to be normal significantly faster than the tone-ABR, and requires about the same or slightly less time to indicate "no response" at screening levels. Consequently, at BC Children's Hospital we typically begin diagnostic tone-ABR assessments with multiple ASSR at a screening level to quickly establish normal vs. elevated thresholds for four frequencies in both ears.

P13

ASSR THRESHOLDS AND LATENCIES OBTAINED IN YOUNG, HIGH-RISK INFANTS

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The current study describes thresholds and latencies of multiple-stimulus auditory steady-state responses (ASSRs) in high-risk infants, tested in early infancy. The first objective was to evaluate the diagnostic value of ASSRs for estimating hearing thresholds in very young infants. Therefore, ASSR thresholds were compared between infants and adults with normal hearing, and infant ASSR thresholds were assessed in relation to behavioral hearing thresholds (BHTs). The second and main objective of this study was to gain insight into the mechanisms underlying ASSRs and possible maturational issues involved. To this end, phase delays and latency estimates in both infants and adults with normal hearing were assessed and age-related changes in latency within the infant group were evaluated.

Normal ASSR thresholds were on average 12 dB higher in infants compared with adults. Correlations between ASSR thresholds and BHTs were 0.75, 0.87, 0.87 and 0.79 for 0.5, 1, 2 and 4 kHz, respectively. There was a significant effect of carrier frequency on ASSR latency, with higher carrier frequencies evoking shorter latencies in both infants and adults. Mean latencies in adults were 24.3 ± 1.5, 22.3 ± 1.1, 19.4 ± 1.0 and 18.0 ± 1.1 ms for 0.5, 1, 2 and 4 kHz, respectively. Depending on the data fit of the infant latency estimates, mean latencies were 1.0 ms shorter or 9.5 ms longer in infants compared with adults. In infants, latencies were on average 2.0 ms longer in the youngest infant group (≤0 weeks) relative to the oldest infant group (3-8 weeks). These age-related trends, together with other arguments, point to longer latencies in infants compared with adults.

The results of this study are valuable as a clinical reference for interpreting ASSR results obtained in high-risk infants within their first months of life, and indicate developmental changes occur regarding ASSR latency.

P14

CORTICAL AUDITORY STEADY-STATE RESPONSES TO LOW MODULATION FREQUENCIES

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Beyond hearing threshold estimation, there has been a growing interest in the application of auditory steady-state responses (ASSRs) to evaluate suprathreshold auditory abilities. The aim of this research was to evaluate suprathreshold ASSRs in relation to behavioral speech understanding skills. Since modulation frequencies below 20 Hz are the most prominent in the speech envelope and appear crucial for speech understanding, ASSRs to low frequencies may have the potential of being strongely related to the processes of speech understanding. In a first step, the reliability of low-frequency ASSR recording was evaluated, and the effect of modulation frequency on ASSR amplitude and latency was explored in a group of normal-hearing adults. In a second step, low-frequency ASSR measures were linked to the perceptual outcomes of speech intelligibility for phonemes and sentences in noise in normal-hearing and hearing-impaired listeners.

Large variability in response amplitude was observed between individuals. Within certain frequency ranges, the mean phase delay increased linearly with modulation frequency, indicating a constant latency. Apparent latencies for frequency regions of 8-12 Hz, 18-22 Hz and 26-30 Hz were 117, 102 and 31 ms, respectively. These results point to primarily cortical sources underlying the response generation. Furthermore, significant differences between normal-hearing and hearing-impaired adults were found for ASSR measures that integrated low modulation frequencies of 4, 10, and 20 Hz. Comparing these responses with phoneme identification scores over different stimulus levels showed both measures increased with stimulus level in a similar way (ρ=0.82). At a fixed stimulus level, ASSRs were significantly correlated with speech reception thresholds for phonemes and sentences in noise (ρ -0.45 to -0.53). These results indicate the objective low-frequency ASSRs can be related to behavioral speech understanding independently of level.

The results of this research may provide promising prospects for the application of suprathreshold cortical ASSRs in objective speech audiometry.

P15

THE AUDITORY STEADY STATE RESPONSE IN THE EVALUATION OF COCHLEAR IMPLANT PATIENTS

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Background: With the FDA approval of cochlear implantation in children younger than one year of age and even in multi handicap patients, objective audiometric tools are needed to aid in the decision of candidacy and to estimate hearing sensitivity thresholds in the implanted child or difficult-to-test patient. The ASSR could be useful for such purposes. However, some studies have found artifactual contamination in the recordings of cochlear implant users.
Aims: The goals of this study were twofold (1) to investigate the usefulness of ASSR to estimate hearing sensitivity thresholds in cochlear implant patients, (2) to investigate the auditory origin of the response.
Methods: Auditory steady state response evoked by single or multiple amplitude modulated tones (0.5, 1, 2 and 4 kHz) were recorded in sixteen children before and after cochlear implantation. The ASSR recordings were obtained inside of the sound attenuated room using the AUDIX system (NEURONIC S.A.). The physiological and behavioral pure tone thresholds were determined in each subject (with earphones before and in free field after CI). The changes with stimulus intensity and the effects of a masking noise over the magnitude of the signal were also investigated.
Results: The ASSR thresholds were found close to the behavioral thresholds in all subjects and conditions studied with mean differences of 4 ± 15 dB. The measured signals had average amplitudes (across tested frequencies) of 0.17 ± 039 μV (minimum 0.003 and maximum 2.8 μV).The amplitude-intensity growth function was non-linear. No detectable responses were found below the behavioral thresholds, and the magnitudes of the signals were reduced by using masking techniques.
Conclusions: The ASSR could be a useful tool for the objective estimation of hearing sensitivity thresholds in cochlear implant children before and after implantation. In all these results substantiate the physiological origins of the ASSR recorded in CI users.

P16

AUDITORY STEADY STATE EVOKED RESPONSES FOR PRETERM AND TERM NEONATES

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Hearing thresholds were estimated in normal-hearing term and preterm neonates of below 35 weeks of age using multiple-stimulus auditory steady-state responses (ASSRs). Thresholds, expressed in dB SPL, at signal frequencies of 500, 1000, 2000 and 4000 Hz were 44.30±9.88, 27.80±6.79, 26.77±6.09 and 32.87±6.12 for the Term group and 49.11±9.44, 26.38±6.59, 26.74±7.57 and 35.90±8.23 for the Preterm group. Significant threshold differences were measured between groups at 500 and 4000 Hz, while thresholds at 1000 and 2000 Hz were similar. Signal and noise levels as well as signal-to-noise ratio (SNR) of responses were also measured and found to be similar. These results indicate that ASSRs can be effectively measured with a similar SNR in both groups, but that there is a significant maturational effect occurring during gestation at the level of structures which participate in the formation of the ASSR at 500 and 4000Hz.

P17

AUDITORY STEADY - STATE RESPONSES IN CHILDREN WITH SENSORINEURAL HEARING LOSS

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Background: Recently, the auditory steady-state response (ASSR) has been suggested as an alternative to the frequency specific auditory brainstem response (FEABR) to estimate the hearing threshold in children who are unable to carry out the tests with conditioned behavioral hearing procedures. Aim: The purpose of this study was to verify the applicability of ASSR to estimate the hearing thresholds in children with sensorineural hearing loss, comparing them to other procedures available for this assessment. Methods: The study included 15 children ages between 2 months and 3 years old, with sensorineural hearing loss. The ASSR obtained in 1, 2 and 4 kHz were compared with click ABR; the ASSR at 0.5, 1, 2 and 4 kHz were compared with the FEABR and with the visual reinforcement audiometry (VRA). Results: The results showed good concordance between the ASSR at high frequencies and the responses for click ABR (0.63 - 0.70), being the best correlation for 1 kHz (0.70). When compared to FEABR it could be seen good concordance between the techniques, with coefficients of 0.77, 0.60, 0.66 and 0.50 for the frequencies of 0.5, 1, 2 and 4 kHz. However, the best coefficients were comparing the ASSR with the VRA (0.89 - 0.93), indicating strong correlation between the techniques. Conclusions: The results showed that when compared to other procedures available to estimate the hearing, the ASSR provided similar findings, proving to be a viable technique in order to estimate the hearing thresholds in a child when the VRA may not be possible.

Key words: auditory evoked potential, hearing loss, children, infants

P18

TONE BURST AUDITORY BRAINSTEM RESPONSE AND AUDITORY STEADY-STATE RESPONSE FOR INFANTS

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Background: Audiological diagnosis in the first weeks or months of life has increased with the consolidation of newborn hearing screening programs. Otoacoustic emissions (OAE) and auditory brainstem response (ABR) with click stimuli are widely used for this purpose. For a successful early intervention, accurate information about type, grade, and configuration of hearing loss become necessary. ABR with tone burst stimuli (TB ABR) and auditory steady-state response (ASSR) exams have been of great value, inasmuch as these tests provide specific frequency information, allowing a more detailed hearing evaluation. Aim: Analyze the clinical applicability of TB ABR and ASSR to predict normal psychoacoustic threshold at 2 kHz, in full-term and premature infants. Methods: The study was conducted at UNIFESP. Subjects were consisted of 17 premature infants and 19 full-term infants, of both genders. In natural sleep, they were submitted to TB ABR and ASSR exams (Smart EP - Intelligent Hearing Systems), under 2000 Hz frequency. Results: Right and left ears responses showed no statistically significant differences, allowing to consider them as a whole. Wave V mean latencies in TB ABR were 7.9 ms to 80 dBnHL, 8.9 ms to 60 dBnHL, 9.9 ms to 40 dBnHL and 10.8 ms to 30 dBnHL. Electrophysiological minimum response obtained with TB ABR was 32.4 dBnHL (52.4 dBSPL), on average. ASSR minimum obtained was 13.8 dBHL (26.4 dBSPL), on average. TB ABR and ASSR exams lasted 21.1 min and 22 min, respectively. Premature and full-term infants responses showed no statistically significant differences, except for ASSR duration. Conclusions: Both TB ABR and ASSR have clinical applicability to predict normal psychoacoustic threshold at 2 kHz in infants, with no differences between premature and full-term individuals.

P19

THE RELATIONSHIP BETWEEN ECAP RECOVERY FUNCTION AND SPEECH PERCEPTION IN IMPLANTED CHILDREN WITH AUDITORY NEUROPATHY : PRELIMINARY RESULTS

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Background: Cochlear implantation has been reported to be successful for rehabilitation of children with auditory neuropathy (AN). The ability of the cochlear implant user to understand speech may depend on the ability of the auditory system to process temporal information. Temporal processing deficits have been reported for individuals with AN. We hypothesize that ECAP recovery functions of implanted children with AN may reflect temporal processing ability in the level of auditory nerve.
Aim: The purpose of this study was to evaluate the restoration of temporal processing abilities in implanted children with AN using ECAP recovery function. Methods: Speech perception measured by monosyllabic word test and ECAP recovery functions in implanted children with AN were compared to those of implanted children with sensorineural hearing loss (SNHL). Results: The slopes of the ECAP recovery function in most children with AN were not differ significantly from those of children with SNHL. The group of children with good ECAP recovery functions showed good performance except children with multiple disabilities. However, the group with poor ECAP recovery function / no ECAPs showed poor performance.
Conclusions: The results of this study show that the refractory properties of the auditory nerve may be a useful index to predict outcomes in implanted children with AN. Good performance means that temporal processing ability can be restored to some degree by electrical stimulation through a cochlear implant. Continued research in the field of electrophysiology to reveal the exact nature of the lesions in patients with AN is needed to establish the role of CI in management of patients with AN.

P20

A POSSIBLE METHOD FOR THE REMOVAL OF COCHLEAR IMPLANT ARTIFACT

FRIESEN, L.M.[1], PICTON, T.W.[2]

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Background: When using auditory evoked potentials (AEPs) as an objective measurement of hearing in individuals having a cochlear implant (CI), the electrical artifact generated by the implant can overlap the neural response and make it difficult or impossible to measure. Since physiological responses increase in amplitude as the interstimulus interval (ISI) increases, we examined the effect of recording responses at two ISIs. Since the artifact does not change with ISI, the difference between the responses should show evidence for the physiological response without artifact contamination.
Aims: 1) To determine the effects of ISI manipulations in a random design on the N1-P2 response and examine ISI-difference waveforms, 2) to determine the effects of varying the ISI and stimuli within or across recording blocks, examine ISI-difference waveforms, and 3) to determine whether a subtraction technique eliminates the artifact in the N1-P2 responses recorded in CI listeners.
Methods: 1) N1-P2 responses were recorded using a speech syllable and tone, paired with ISIs that changed randomly between 0.5 and 4 seconds in 10 normal hearing listeners. Difference waveforms were then analyzed. 2) The same stimuli, at either 500 or 3000 ms ISI, in block designs were used to evoke the N1-P2 responses in 8 normal hearing individuals and difference waveforms were examined. 3) N1-P2 responses were then recorded using pulse trains with 500 and 3000 ms ISIs in 4 CI listeners, and difference waveforms were computed. Results: 1) N1-P2 response amplitudes generally increased with increasing ISI. Subtraction waveforms were similar in latency and scalp distribution to the unsubtracted waveforms. 2) N1-P2 responses were larger for the 3000 ms condition compared to the 500 ms ISI condition. Difference waveforms were largest for the random stimulus design. 3) The subtraction technique eliminates the electrical artifact in individuals with cochlear implants and leaves a measurable N1-P2 response. Conclusions: The subtraction technique appears to be a feasible method of removing from the N1-P2 response the electrical artifact generated by the cochlear implant.

P21

AUDITORY NEUROPATHY AND BRAINSTEM CONTROL OVER THE OUTER HAIR CELLS

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Summary: the auditory perception depends on an elaborated and complex system that is capable of executing an intelligent and dynamic filtering of the sounds that reach the human ear. Part of this filtering seems to be related to the acoustic reflexes. Not only do patients with auditory neuropathy (AN) have intense disturbance to the ability of recognizing speech but they also have modifications in the location where most of the known reflexes occur. This location has been defined by the presence of low speech-awareness threshold and otoacoustic emissions and the absence of auditory brainstem response waveforms. The olivocochlear and the stapes reflex have a smoothing effect over inner and external ear, respectively. Thus, patients who have dysfunctional reflexes are good models to study them.
Objective: Evaluate the brainstem action over the cochlea in patients with auditory neuropathy. Methods: 30 patients with AN and 30 control subjects underwent a complete audiologic evaluation, stapes reflex and distortion product otoacoustic emissions (DPOAE) analysis. Results: The distortion product otoacoustic emissions amplitude, in 1000Hz, were higher in patients with AN than in controls(13,0 vs 9,18 dBNPS, p=0,0007). The differences in other frequencies were not significant.
Conclusion: The auditory reflexes failure in patients with AN interferes in the brainstem control over the cochlea.

P22

STAPES REFLEX AND SPEECH RECEPTION THRESHOLD (SRT) IN PATIENTS WITH AUDITORY NEUROPATHY

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SANTA CASA DE SÃO PAULO, BRAZIL

Patients with auditory neuropathy (AN) have great difficulty in the ability of speech recognition and alterations in the location where the most known reflexes occur. This location has been defined by the presence of low speech-awareness threshold and otoacoustic emissions and the absence of auditory brainstem response waveforms. There are no current parameters to measure the intensity of the AN. We believe the intensity of the reflexes dysfunction is related to the patient's complaint, that is, his ability to recognize speech.
Objective: evaluate the presence of auditory reflexes in patients with AN and verify possible relations with SRT.
Materials and Methods: we studied 30 patients with AN and compared their SRT and stapes reflex. They were divided according to reflexes presence or not in 1000Hz and the data was analyzed using ANOVA.
Results: We verified that SRT average for two syllable words was higher in "with reflex"(53,42%) group than in "without reflex"(22,25%) group. The analysis was statistically significant (p=0,0014).
Conclusion: The stapes reflex is related to the SRT impairment degree in patients with auditory neuropathy.

PII-1

THE RELATIONSHIP BETWEEN ELECTRICALLY EVOKED COMPOUND ACTION POTENTIAL AND SPEECH PERCEPTION IN HYBRID COCHLEAR IMPLANT USERS

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Abstract: Background and Aims: Several studies have examined the relationship between physiological and/or psychophysical measures and auditory nerve survival in animal subjects. Some have shown a relationship between the growth of response and nerve survival. More recently, Prado-Guitierrez et al. (2006) showed a relationship between the current differences using two inter-phase gaps (IPGs) and nerve survival. One may hypothesize that nerve survival in a cochlear implant may be related to the effectiveness of the implant and consequently to individual scores on speech perception tests. Studies relating physiological measures such as ECAP and EABR threshold and growth have not shown clear relationships to speech perception abilities. We revisited this question in users of the Nucleus hybrid implant. Our hypothesis was that with a short electrode array, there would be more uniformity in the response properties across electrodes within an individual. In that way, there might be more across subject differences and physiological measures may better characterize the individual subject. Methods: We measured ECAP growth functions to biphasic pulses with two IPGs in twelve hybrid implant users. We then calculated 1) the current difference (the change in current level required to record ECAPs with the same amplitude) using two IPGs of 8 and 45 μs, and 2) the slope of the growth function. For each subject, these measures were compared with performance on tests of word recognition.
Results: The current differences using two IPGs showed no correlation with results of word recognition test. In contrast, relatively strong correlations (r=0.7822) have been found between the slope of ECAP growth functions and performance on word recognition test. Conclusion: Effectiveness of the hybrid implant can be quite variable. These results show that ECAP measures may be useful in developing a test to predict outcomes with the implant.

PII-2

STABILITY OF AUDITORY EVOKED POTENTIALS: MIDDLE AND LATE RESPONSES

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Introduction: Middle and late latency responses have limited acceptance for clinical use due to little evidence for their test-retest stability and to different normative values among laboratories because modifications in recording and stimulating parameters. Objective: The aim of this investigation was to evaluate test-retest stability of middle and late latency auditory evoked potentials in healthy individuals. Methods: Three studies were made with 8 - 16 years old subjects: middle-latency response (Na/Pa amplitude and Pa latency) with 30 subjects; N1-P2-N2 complex (N1, P2 and N2 latencies; N1-P2 and P2-N2 amplitudes) with 22 subjects; and P300 (latency and amplitude) with 29 subjects. All of them were evaluated twice, verifying the test-retest stability of the middle or late latency responses over 3 months. All subjects had a normal middle ear function and normal hearing sensitivity. They had no medical history of neurologic pathology, head trauma and no language problems at the time of evaluation as determined by speech-language pathologist. Results: Middle-latency response, N1-P2-N2 complex and P300 results showed no statistically difference ($p>0,05$ - ANOVA) between first and second condition either for amplitude and latency for all electrodes site and for all components. Means in all comparisons and for all components were very similar, despite standard deviation was not too small sometimes. These results reflect inter-individual variability for each response, but also indicate individual stability of middle and late latency responses. Conclusion: The sufficiently high individual stability of the middle and late latency responses support the utility of these measurements for research and clinical practice in this age group, especially at management of neuronal plasticity resulting from training and perceptual learning.

PII-3

EFFECTS OF AGE ON PERCEPTION AND NEURAL REPRESENTATION OF FREQUENCY

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Older adults, even with clinically normal hearing sensitivity, have difficulty understanding speech in the presence of background noise. This difficulty may be partly due to age-related declines in the neural representation of frequency. The purpose of this study was to examine the effect of age on behavioral and physiological measures of frequency representation. Thirty one adults (ages 21 - 77) with clinically normal hearing sensitivity (equal to or better than 25 dB HL at octave frequencies 0.25 - 8.0 kHz) participated in this experiment. Frequency discrimination was tested at 1000 Hz using a two interval, two alternative forced choice procedure. Frequency-following responses (FFRs) were elicited by tonebursts at 925, 998, and 1000 Hz. Tonebursts of 500-ms duration (15-ms rise/fall) were used for both the behavioral and physiologic conditions. FFRs were analyzed using phase coherence and amplitude. Results showed a decline in behavioral and physiological responses with increased age. Linear regression analysis showed a statistically significant decrease in frequency discrimination with increasing age. Linear regression analyses of phase coherence and amplitude also showed statistically significant decreases with increasing age. Frequency discrimination and FFR measures decreased with increasing age. These results are consistent with age-related declines in the neural representation of frequency. There were concurrent decreases in the perception and physiologic representation of frequency as chronological age increased.

PII-4

THE P300-PEAK, AN OBJECTIVE MEASURE FOR AUDITORY PROCESSING?

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Aim: Evaluation of the P300 as an electrofysiological measure for auditory processing disorders in children.
Introduction: The number of children with auditory processing disorders (APD) tends to increase. Despite a number of available diagnostical tests, it remains difficult to assess apd. The P300 is an electrophysiological measurement that is related to auditory processing capacities and may therefore contribute in the diagnostic process with APD.
Methods: The P300-test is conducted with 34 primary school children (9-12 year of age) with normal peripheral hearing, divided in a control group without APD and a group with a suspicion of APD. In addition a clinical standard for Auditory Processing is assessed by means of a questionnaire of auditory function (CHAPS) and a psychophysical test battery (Nijmegen testbattery for APd). The latencies of the P300 are compared with this clinical standard.
Results: Although the results show a weak correlation between the latency of the P300 and APD according to our clinical standard, there is no significant difference in P300 peak latency between the clinical and control group.
Conclusion: The P300-measurements do not yield a clear difference between children with and without a suspicion of APD, although there is a weak correlation between both measures. Further investigations are necessary to assess the clinical advantage of the P300 as an addition to the contemporary instruments.

PII-5

A POSSIBLE METHOD FOR COCHLEAR IMPLANT ARTIFACT REMOVAL

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Background: When using auditory evoked potentials (AEPs) as an objective measurement of hearing in individuals having a cochlear implant (CI), the electrical artifact generated by the implant can overlap the neural response and make it difficult or impossible to measure. Since physiological responses increase in amplitude as the interstimulus interval (ISI) increases, we examined the effect of recording responses at two ISIs. Since the artifact does not change with ISI, the difference between the responses should show evidence for the physiologial response without artifact contamination.
Aims: 1) To determine the effects of ISI manipulations in a random design on the N1-P2 response and examine ISI-difference waveforms, 2) to determine the effects of varying the ISI within or across recording blocks, examine ISI-difference waveforms and make comparisons to the random design, and 3) to determine whether a subtraction technique eliminates the artifact in the N1-P2 responses recorded in CI listeners. Methods: 1) N1-P2 responses were recorded using a speech syllable and tone, paired with ISIs that changed randomly between 0.5 and 4 seconds in 10 normal hearing listeners. Difference waveforms were then analyzed. 2) The same stimuli, at either 500 or 3000 ms ISI, in block designs were used to evoke the N1-P2 responses in 8 normal hearing individuals and difference waveforms were examined. 3) N1-P2 responses were then recorded using pulse trains with 500 and 3000 ms ISIs in 4 CI listeners, and difference waveforms were computed. Results: 1) N1-P2 response amplitudes generally increased with increasing ISI. Subtraction waveforms were similar in latency and scalp distribution to the unsubtracted waveforms. 2) N1-P2 responses s were larger for the 3000 ms condition compared to the 500 ms ISI condition and difference waveforms were larger for the block design vs. the random design. 3) The subtraction technique eliminates the electrical artifact in individuals with cochlear implants and leaves a measurable N1-P2 response. Conclusions: The subtraction technique appears to be a feasible method of removing from the N1-P2 response the electrical artifact generated by the cochlear implant.

PII-6

CORTICAL & BEHAVIORAL ENHANCEMENT OF SPECTRAL PEAK RESOLUTION BY AUDITORY TRAINING

See Youn Kwon.[1,2], Jun Sic Kim.[3], Chun Kee Chung.[3], Heepyung Kim.[1], In Young Kim.[1], Sun I Kim.[1], Sung Hwa Hong.[2]

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Discrimination task of inverting spectral-ripple (SR) noise introduced as one of the most efficient non-linguistic psychometric test to measure of spectral-peak resolution in normal and hearing impaired (Henry et al 2005; Won et al. 2007). In this study, we investigated the effect of ongoing spectral discrimination training on behavioral and physiological spectral-peak resolution changes. Ten normal-hearing subjects participated in four times of behavioral discrimination trainings, and a behavioral test along with an MEG recording was conducted before and after training. SR stimuli were four seconds in duration; the first 2 seconds consisted of a standard ripple and the last 2 seconds were either an inverted ('with changed') or a standard ripple ('without changed'). The ability to behaviorally detect changes within the SR stimuli were measured using a 1-interval, 2-alternative forced-choice paradigm. In the training sessions, the feedback was provided. Cortical responses were recording using 306 channels MEG system. The results from training-induced changing of behavioral and physiological perception showed that a subject's behavioral ripple discrimination ability improved after training. Our results suggest that perceptual improvement in detecting the spectral-change cause more neural synchronies through the central auditory system, and it possibly reflects that the ACC amplitude increased. [supported by KRF-2006-612-D00106, HY-2007-1]

PII-7

AUDITORY EVENT-RELATED POTENTIALS IN SCHOOL-AGED CHILDREN WITH HEARING LOSS

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Introduction: Auditory sequential organization (ASO), which is one of the central auditory capacities, refers to ability to keep in proper order the acoustic elements of a sequence. Results of ASO studies suggest that the individuals with sensorineural hearing loss usually show significantly lower performance than their control peers. However, based on these studies, the nature of the difficulties of children with hearing loss is not fully understood. Are the poorer performances on ASO tasks associated with perceptual difficulties or due to speech perception deficits? Purpose: The main objective of the current research project is to investigate the relation between the peripheral auditory system and the central auditory system when one of the two systems is not functioning well. More specifically, the objective of the study is to assess the influence of a peripheral hearing loss on the auditory information processing in school aged children. Design: Data collection is in progress. Children between the age of 9 and 12 years old- with a peripheral hearing loss, with auditory processing disorder and with normal hearing function, are participating in the study. Behavioral and electrophysiological measures are used in this investigation. For behavioral measures, children perform an ASO task by recalling two, three and five verbal and nonverbal stimuli with a fixed interstimulus interval (ISI). Children reproduce also sequences of two elements with a variable ISI. For the electrophysiological measures, auditory event-related potentials to standard and deviant verbal and nonverbal stimuli presented in a passive oddball paradigm will be investigated. Auditory principal components, P1, N1, P2, N2 and mismatch negativity, MMN, are studied in three groups of children. Results: Differences in psychoacoustic and electrophysiologic data are expected between three groups of children, for the verbal and nonverbal stimuli.

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PII-8

AUDIOVISUAL SPEECH PERCEPTION MEASURED USING EEG AND MEG RECORDINGS OF CORTICAL AUDITORY EVOKED POTENTIALS IN ADULTS WITH NORMAL HEARING

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Background: It is widely accepted that speech perception is enhanced by the presence of auditory and visual cues in both quiet and noisy situations. The addition of visual cues to an auditory alone condition is believed to create the illusionary perception of the sound becoming louder, and a mismatch between auditory and visual cues (the well known "McGurk effect") can lead to the illusionary perception of a speech sound that was not presented). Audiovisual speech perception is of interest as the perceptual integration that occurs in adults may not be present in young children, hearing impaired individuals or people with auditory processing disorder.
Method: Cortical auditory evoked potentials (CAEPs) were recorded using both electroencephalography (EEG) and magnetoencephalography (MEG) techniques in response to the natural speech tokens /ba/, /da/, and /ga/ presented as auditory only, visual only, and audiovisual stimuli, presented in randomised blocks. Audiovisual stimuli were either congruent (same auditory and visual stimulus) or incongruent (different auditory and visual stimulus, in order to create the McGurk effect). Participants were adults with normal hearing. They pressed a button to indicate what they perceived each time a stimulus was presented. Evoked responses recorded from a range of scalp locations and reaction times were analysed.
Results: Reaction times and evoked responses were affected by stimulus congruence. Evoked responses consisting of visual onset responses, the response to the speech gesture (when the lips moved to produce the speech sound), and an auditory onset response. The response to the audiovisual stimuli was not a simple sum of the auditory and visual responses, and responses to congruent and incongruent stimuli differed. Responses to audiovisual stimuli had a broad scalp distribution.
Discussion: The results indicate that it is possible to investigate audiovisual interactions objectively using electrophysiological techniques.

PII-9

THE INFLUENCE OF JET ENGINE NOISE ON HEARING

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Objective: The aim was to assess the effects of exposure to jet engine noise on distortion product otoacoustic emissions (DPOAEs) and in comparison to pure tone audiograms (PTA) in jet engine servicing personnel.
Study design and setting: The study comprised 60 men exposed to jet noise and 50 men not exposed. The measurements of noise emitted by three jet engines were performed. DPOAE and PTA were recorded in both group.
Results: Jet engines emitted broadband noise with spectrum dominated by components in the frequency range 315 - 4000 Hz. Maximum A-weighted sound pressure level, LA max (dB) reached values of approx. 119.7-130.1 dB. Greater reductions of DPOAE levels were mainly for the frequencies of 3, 4 and 6 kHz, in the group exposed to noise.
Conclusion: The reduction of DPOAE in individuals exposed to jet engine noise was greater than the changes in conventional tonal audiograms. Frequencies affected in cochlea corresponded to highest intensity level frequencies emitted by engines.
Significance: The technical personnel participating in jet engine tests (even in the case of a single exposure) are exposed to noise which greatly exceeds permissible and safe levels.

PII-10

MEDIAL OLIVOCOCHLEAR SUPPRESSION AND TEMPORARY OTOACOUSTIC EMISSIONS SHIFT IN HUMAN EARS EXPOSED TO NOISE.

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It has been hypothesized that one of the medial olivocochlear (MOC) efferent system function is to protect the ear from noise overexposure. Animal studies have shown that electrical stimulation of the olivocochlear bundle reduces temporary threshold shifts, and chronic olivocochlear section increases permanent threshold shifts. Despite growing understanding of MOC physiology it remains uncertain whether such effect is also existent in humans. The aims of our study were: a) to evaluate correlation between MOC reflex strength and degree of temporary distortion product otoacoustic emissions (DPOAEs) level shifts after short-term noise exposure and b) to investigate the relationship between recovery of cochlear function after noise exposure and MOC suppression. To evaluate the function of MOC system click evoked otoacoustic emissions (CEAOEs) were recorded in 44 right-handed, normal hearing subjects with and without continuous contralateral broadband noise (BBN) stimulation at 50 dB SL. Contralateral suppression effect was defined as the difference in the level of the OAE waveform between the no-noise and noise conditions. Than DPOAE grams at L2= 50 dB SPL (L1=0.4L2 +39; f2/f1= 1.22) were recorded from 1.0 to 5.0 kHz before and several times after noise exposure (BBN at 100 dB SPL, exposure time - 20 minutes). There was no significant correlation between DPOAEs level shifts after noise exposure and MOC suppression, however some relationships were observed between MOC reflex strength and time of DPOAEs recovery after noise exposure.

PII-11

DETECTION OF LONG LASTING AND SPONTANEOUS COMPONENTS OF CLICK-EVOKED OTOACOUSTIC EMISSIONS BY MEANS OF MATCHING PURSUIT ALGORITHM

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Spontaneous otoacoustic emissions (SOAEs) are often visible as narrow peaks within click-evoked otoacoustic emissions (CEOAEs) spectra. Their presence may be demonstrated even more clearly using time-frequency (t-f) distributions that show the energy of the evoked emissions, where they form a continuous trace of energy that spans the whole length of the signal. In the present study CEOAEs were measured in 20 and 80 ms intervals between click stimuli. The responses obtained were decomposed into basic waveforms by means of adaptive approximations using a Matching Pursuit (MP) algorithm. The method allows for description of the signal components in terms of frequencies, time occurrences, time spans, and energy. The main advantage of this method over techniques such as filtering and wavelets is that the signal is not divided into frequency bands. For the same frequency several components having different time occurrences can be extracted. These waveforms can also have different duration which can be evaluated by their time span parameter. This approach made possible observation of three types of component: (1) purely evoked of duration less than 5 ms, (2) longer lasting and decaying, with exponentially decreasing amplitude, and (3) long lasting and stable which can be considered as SOAEs. The prevalence of spontaneous and long lasting components determined using MP analysis was similar to the results in previous reports that were obtained using different methods. MP analysis can be used as a tool for the automated detection of SOAEs and is capable of distinguishing decaying components from stable ones. By increasing the acquisition window and applying t-f analysis, one can combine the measurement of evoked and spontaneous emissions.

PII-12

OTOACOUSTIC EMISSIONS AND EFFUSION IN THE MIDDLE EAR

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The association of otoacoustic emissions with brainstem evoked acoustic potentials and clinical exam has been considered the best screening method to detect auditory deficiency. Nevertheless, the universality of the exam has been questioned due to problems related to the interference that may occur when there is liquid in the tympanic cavity. As is very well known the high prevalence of effusion in children between 2 and 6 years-old, as well as the real possibility of its occurance in neonates, the knowledge of which is the actual interference could help in the evaluation of the results of the OAE. So far, the investigation has focused on the study of clinical data of patients with middle ear effusion submitted to OAE. There aren't studies about the relationship of the fluid volume and viscosity with the result of OAE. Aim: To establish the relationship between the presence and quality of liquid in the middle ear and the response of the OAE - transient, spontaneous in guinea pigs. Material and Method: 53 guinea pigs, about 400g and 3 months old were studied. They were submitted to tympanotomy and received a certain amount of liquid in three different volume and density. They were grouped according to the liquid received. The OAE were accomplished before and after the injection. The pre test exam was the control. After the second exam all animals were sacrificed and its middle ears were histologically analyzed. The results were compared statistically. Results: The results show clear distinction between the study groups and control, in some specific frequencies. Besides, the results were shown dependence of the amount and quality of the liquid. We could observe a progressive reduction in the number of abolished frequencies, increasing as the amount of liquid increased. Conclusions: the viscosity and amount of the liquid in the medium ear of guinea pigs are decisive of specific modifications in the otoacoustic emissions distortion product in guinea pigs.

PII-13

HEARING DIAGNOSTICS IN INFANTS BY MEANS OF EXTRAPOLATED DPOAE I/O-FUNCTIONS AND PURE-TONE THRESHOLDS

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The purpose of the present study was to investigate the test-performance and the efficacy of the novel method in newborn and pediatric audiometry using extrapolated DPOAE I/O-functions. Applying such method, cochlear hearing thresholds can be estimated (Boege and Janssen 2002, Gorga et al. 2003) and presented in the form of a 'cochleogram' (Janssen et al. 2006)

DPOAEs provide frequency-specific and quantitative information about cochlear impairment.
DPOAE I/O-functions (L2 = 15 to 65 dB SPL) were measured between 1.5 and 6 kHz. DPOAE-audiograms (derived from the extrapolated DPOAE I/O-functions) were obtained in 100 newborns within the early post-natal period (mean age 2 1/2 days) and in 148 children aged between 1/2 to 15 years. Measurements were done using a hand-held device.
In the newborns, the estimated hearing threshold was below 15 dB on average across test-frequencies. There was no significant difference between both ears indicating a high test-retest stability of the method. Mean thresholds lowered with increasing age (1 day 15.4 dB, 2 day 14.4 dB, > 3days 9.4 dB) and may be due to residual amniotic fluid in the tympanic cavity. In the pediatric group the difference between estimated and behavioural thresholds decreased with increasing age from 40 to 5 dB on average. Measuring time for establishing a DPOAE-audiogram took up from two to ten minutes depending on the hearing loss.
Beside the physiological test, a new hand-held device (PATH Medical, Germany) offers a psycho-acoustical test based on a 'Multiple-choice Auditory Graphic Interactive Check' (MAGIC). Pure-tone thresholds were determined by selecting icons (animals) from the touch-screen of the hand-held device that "produces" sounds with different frequencies and sound pressure levels. The test run was controlled by the child itself. There was a close correlation between the child's pure-tone behavioural threshold and the threshold obtained by the new method.
The findings suggest the novel methods being very useful and suitable for follow-up diagnostics in hearing-screening programs as well as for assessing cochlear hearing loss in pediatric audiometry.

PII-14

SCREENING NEONATES WITH MSSR TO SIMULTANEOUSLY PRESENTED BONE- AND AIR- CONDUCTED STIMULI.

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Background: With the rapid growth of universal neonatal hearing screening, the methods and technology for early detection of hearing impairments need to be continuously perfected. An important goal is to reduce the false positive rate in the initial screen due to transient conductive impairments.
Objectives: To evaluate the diagnostic efficiency and overall performance of an automatic MSSR screening device using simultaneous bone- and air- conducted stimulation.
Methods: A sample of 24 infants (46 ears) with and without high risk factors was screened within 3 days of birth. Each infant (ear) was tested twice (in random order) with MSSR to simultaneous bone- and air-conducted stimuli and with automatic EOA (Accuscreen, Madsen). All babies (pass/fail) were followed up and re-evaluated within 1 month of age with: 1) standard MSSR and EOA; 2) Otoscopy and Impedance testing. The MSSR stimuli were two amplitude modulated (95% depth) carrier tones (500 & 2000 Hz) presented simultaneously through bone- (B71) and air- conducted (Eartone 5A) transducers. The intensities were fixed at 30 and 40 dB HL for BC and AC stimuli respectively. The pass/fail intensity criterion was previously established (100% response detectability) in control groups of 15 healthy infants.
Results: Both automatic screening devices performed adequately in the maternity ward, showing similar pass/fail results in most (77%) tested ears. The diagnostic sensitivity and specificity rates were much better though for the MSSR (100% and 95%) than for the AOAE (50% and 83%) screening test. This was due to the MSSR correct identification of 9 of the 11 screen failures classified as ¨transient conductive impairments¨ and the detection of a sensorineural hearing loss than passed the OEA screen.
Conclusions: The automatic MSSR screening device performed adequately in the maternity ward identifying more efficiently transient and permanent impairments missed by an AOAE.

PII-15

ASSESSMENT OF HEARING IN THE ELDERLY: AGING AND DEGENERATION - INTEGRATION THROUGH IMMEDIATE INTERVENTION - AHEAD III

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Hearing loss is one of the most common chronic health conditions in the elderly population with important implications for patient quality of life. The diminished ability to hear and to communicate is frustrating in and of itself, but the strong association of hearing loss with depression and functional decline adds further to the burden on individuals who are hearing impaired. Hearing loss can limit communications skills: not to hear means not to understand what is being said. Hence deafness does not produce compassion but do often produce a sense of imitation. Despite the prevalence and burden of hearing loss, hearing impairment is largely underdiagnosed in older persons and undertreated. The reason for this is that one of the most conspicuous signs of a hearing loss is that it cannot be seen! Actually, this is the reason why deafness does not receive the necessary attention. Too often, the public and still too many health care professionals underestimate the dramatic effects of deafness. Novel strategies should be explored to make screening and early intervention a feasible part of routine care. Project AHEAD III has been specifically designed too: Provide evidence of the effects of hearing impairment in adults and particularly in the elderly. Analyse costs associated with the implementation of integrated large scale programmes of hearing screening and intervention in the elderly. Provide quality standards and minimum requirements for screening methods and related diagnostic techniques. Develop guidelines and recommendations on how to implement successful screening programmes to be tuned to the local, social, and economical conditions of a country. Acknowledgment: Supported by the 7th EC Framework Programme - Project acronym: AHEAD III, Grant agreement no. 200835. Project Co-ordinator prof. Ferdinando Grandori (Italy)".

PII-16

USE OF ASSR PHASE IN NEWBORN HEARING TESTING

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Objective: For fixed stimulus parameters, the phase of the auditory steady-state response is distributed within a predictable range of values in a given population. The circular mean of this distribution can be used to bias response detection to favor results which are similar to the expected phase. In this study, the phase-weighted t-test is compared to the F-test for the detection of auditory steady-state responses in a newborn population.
Methods: Multiple auditory steady-state responses were elicited at modulation rates between 78 and 95 Hz in a newborn population aged <15 weeks. Sixty-five ears of fifty-nine infants were analyzed. Carrier frequencies of 500, 1000, 2000, and 4000 Hz were presented simultaneously at 55 dB SPL to each ear with exponential (sine-squared) amplitude modulation. Test duration included up to 45 sweeps of data (16.384 s each). The F-test and phase-weighted t test were compared as detection algorithms.
Results: Across carrier frequencies using standard cumulative averaging, the phase-weighted t test can detect 93 responses out of 260 possible responses (65 ears by 4 carriers). The F test detected only 86 responses. The phase-weighted t-test detected the response after fewer sweeps in the cumulative average in 44 cases, whereas the F test was faster in only 10 instances. When weighted cumulative averaging was used, the differences between the two tests were smaller. The phase-weighted t test detected 169 responses and was faster than the F test in 83 cases. The F test detected 162 responses and was faster in only 19 cases.
Conclusions: The phase-weighted t-test is more effective than the F-test for rapidly detecting the auditory steady-state response in newborns. This result is similar to that found previously in adults, which has shown that using both amplitude and phase to detect evoked responses provides more benefit than using only one of these measures.

PII-17

POSSIBLE CONFUSION BETWEEN VEMP AND PAM RESPONSES

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The vestibular evoked myogenic potential (VEMP) is recorded from the sternocleidomastoid (SCM) muscle of the neck, in response to loud acoustic stimuli, and originates from the saccule. It is an inhibitory potential with a latency of 12-15 ms. The post-auricular muscle (PAM) response is an excitatory potential evoked in response to stimulation of the cochlea, with a similar latency to the VEMP. Recording of either response requires tension in the neck muscles.
In most clinical conditions there is no confusion between these responses. However, many stimulus and recording parameters are similar for the two responses and there are some situations where some confusion might be possible. One example is when a patient has had chemical ablation for Meniere's disease and is being tested for residual vestibular function using VEMP responses. Is there any possibility that a small response could actually be a PAM response recorded from SCM electrodes?
Simultaneous recordings were made, on normal subjects, using bilateral recording electrodes on SCM and PAM sites, using a variety of reference electrodes, in response to unilateral clicks and 500 Hz tones at 50, 75 and 95 dB nHL. Recordings were made in three head/body positions (i) supine with head raised, (ii) body/head upright and (iii) body upright with head flexed downwards. Findings were as follows: (i) VEMP responses were obtained only in the supine/head raised condition, suggesting that clinical PAM recordings are unlikely to be contaminated by VEMP responses, (ii) VEMP recordings with a sternum reference tended to produce "bilateral" responses due to volume conduction, (iii) PAM responses were often recorded in the supine/head raised position (from PAM electrodes), (iv) The PAM response can be recorded from electrodes at least 5-6 cm inferior to the mastoid, due to volume conduction, and could therefore be recorded by an electrode on the SCM muscle.

PII-18

MELATONIN IS A USEFUL ALTERNATIVE TO SEDATION IN CHILDREN UNDERGOING BRAINSTEM AUDIOMETRY

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Though brainstem audiometry is one of the most important investigations in pediatric audiology, it often necessitates sedation or general anaesthetics, especially in newborns and infants. Melatonin, inducing natural sleep without the risks of sedation, has been successfully used to induce sleep prior to EEG investigations. 250 children (142 male, 108 female) with suspected hearing loss underwent ABR (auditory brainstem responses) tests in melatonin-induced sleep. Click-induced and notched-noise ABR tests were performed. Click tests were successfully performed in 216 of 249 children or 86.7 % (123 male, 93 female), notched-noise tests in 115 of 155 children or 74.2 %. Failure rates showed an age dependence increasing from 4 % in children < 1 year to 25 % > 3 years, but no gender difference. In conclusion, melatonin-induced sleep offers a good alternative to sedation, especially in children younger than 3 years. It is very useful in the follow-up of children that failed in newborn hearing screening. Although the application of melatonin, in Germany, is an off-label-use, this method is widely accepted by parents and permits earlier diagnosis of hearing impairment in a routine clinical setting. The number of children undergoing general anaesthesia for ABR measurement could be reduced over 80%.

PII-19

CORRELATION BETWEEN INTRA-/POSTOPERATIVE ECAP LEVELS AND PROGRAMMING PARAMETERS IN COCHLEAR IMPLANT USERS.

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BACKGROUND: Initial fitting of very young children and difficult to program cochlear implant recipients is usually based on the results of objective measurements. That's why it is extremely important to find a correlation between measurements outcomes and programming parameters of the patients MAP's which will facilitate the ECAP-based fitting procedure. With the introduction of the Nucleus Freedom implant with the new automatic algorithm techniques of measurements (AutoNRT), it is necessary to establish the relationship between the intra-/postoperative NRT thresholds and their usability for speech processor fitting.
AIMS: The aim of this study was to evaluate the results of post- and intraoperative AutoNRT measurements, examine changes that may occur over the time and to find the correlations between intra-operative NRT measurements and the behavioral MAP parameters (T- and C-levels and profile) in pediatric users.
METHODS: 18 patients implanted with the Nucleus Freedom system who were able to set psychophysically reliable T- and C- levels, were included in the study. AutoNRT was measured intraoperatively and during the postoperative period. Behavioral levels were measured at the first fitting and 3, 6 and 12 months after the switch-on.
RESULTS: A decrease of the NRT-thresholds over the time has been observed in most cases. The C-level were always above Auto-NRT thresholds. The mean difference and correlations between the intra-operative NRT data and behavioral measures and the correlation between them will be presented.
CONCLUSIONS: The NRT-levels as measured intra-operatively decrease in most cases after initial fitting. The medium to high correlation between AutoNRT and behavioral thresholds were demonstrated. The intra-operative ECAP thresholds, when combined with a limited amount of behavioral data, may therefore be used for the prediction of the behavioral levels and MAP profile with a useful degree of accuracy during the initial fitting.