ABSTRACT BOOK

Lectures - Special Sessions
&
Communications

Lecture

304 - Hearing for Life: World Report on Hearing

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To stimulate public health action against the global rise of hearing loss, the World Health Organization has recently launched the World Report on Hearing. This report provides a **life-course perspective** on ear and hearing problems and outlines various causative and preventative factors that influence one's hearing trajectory and determine our hearing capacity. The impact of unaddressed hearing loss on individuals, families, society, countries and economy is described along with the diverse preventative, therapeutic and rehabilitative interventions that can effectively mitigate this impact. Available and emerging technological and public health solutions in the field of hearing care are detailed, stressing the fact that all people who are at risk of or are living with ear and hearing problems can be benefitted through timely and appropriate interventions.
The Report also deals with the numerous barriers and challenges faced in ensuring equitable access to ear and hearing care in different settings. The epidemiology of hearing loss in the context of ongoing demographic shifts is described. Gaps in human resource availability for ear and hearing care and access to hearing devices are detailed. It looks at challenges related to the often-complex requirements for addressing hearing loss; barriers of knowledge and awareness; and health system barriers. It focusses on potential solutions for addressing these issues, sharing examples from countries across the world.
The Report introduces the concept of ***integrated people-centered ear and hearing care*** and proposes a package of **H.E.A.R.I.N.G. interventions** for implementation by countries. It recommends the integration of ear and hearing care services into national health systems as part of universal health coverage. The Report also describes important aspects of health system that need to be strengthened to ensure that these services are available to all those who need them.
The purpose of this Report is to present an evidence-based narrative on ear and hearing care that makes a case for its inclusion as part of national public health actions. It targets policy makers and decision makers, while also speaking to all stakeholders in the field of ear and hearing care, whose views have been reflected in this seminal document. The World Report on Hearing provides a vital tool with which to influence public health leaders at global, regional and national level, informing them of the need, means and benefits of ear and hearing care and making an irrevocable case for investment in this field.

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Symposium

Sensitive new methods for measuring hearing infants, children and adult

Organized by David Moore and Lisa Hunter

299 - New sensitive technology for auditory threshold measures in infants

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Objectives**:** ASSR allows for testing of 4 frequencies in each ear simultaneously potentially reducing test time. Traditional ASSR has not shown adequate sensitivity near true threshold especially with normal hearing. Recent technological advances in ASSR detection and use of Chirp stimuli may improve accuracy
and speed of infant threshold prediction measures. This study directly measures test time and threshold sensitivity new ASSR technology and compares results to ABR with automated detection in individual clinical cases.
Design: Participants were 102 children referred to three US hospital centers. Electrophysiologic thresholds were obtained at four frequencies in both ears using ABR and ASSR (randomized). Interacoustics Eclipse systems were used for ASSR with updated detection algorithms and for ABR using F_{MP} response detection. Both tests used narrow-band CE-Chirp® stimuli. A specialized test battery was designed to minimize test times. Thresholds were determined, and test times were documented in system software.

Results**:** Corrected thresholds for ABR and ASSR were compared by regression, the Bland-Altman technique and matched-pairs t-tests. Thresholds were significantly lower for ASSR than ABR at all test frequencies. Average test time for ASSR of 19.93 minutes was lower ($p < 0.000$) than average ABR test time of 32.15 minutes. ASSR thresholds plotted in dB nHL for normal hearing children in this study were found to be the lowest yet described except for one study which used the same technology.
Conclusions: This study found lower thresholds when using the ASSR with upgraded detection compared to ABR using a standard automated detection (F_{MP}). Test time was significantly lower with ASSR than ABR but was excellent by clinical standards for both techniques. Improved threshold performance by ASSR was attributed to advancements in response detection including utilization of information at multiple harmonics of the modulation frequency. The use of narrow-band CE Chirps also contributed to the low absolute levels of the thresholds in nHL and rapid test times found with both techniques.

294 - Detection of Slight-Mild Hearing Levels with DPOAE and Wideband Tympanometry

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Objectives: Even slight-mild congenital hearing loss can affect speech-language development and academic progress, but newborn screening and current diagnostic criteria are relatively insensitive to hearing levels below 40 dB HL. Slight hearing loss may be more likely to be conductive in origin, making it more difficult to determine what type of intervention is needed. This study was designed to assess whether distortion product otoacoustic emissions (DPOAE) using age-appropriate norms are sensitive and specific for detection of all degrees of educationally significant hearing loss (>15 dB HL). In addition, wideband tympanometry was employed to assess presence of middle ear dysfunction in relation to degree of hearing loss and DPOAE results. Design: Prospective case control study, randomized for test order with auditory brainstem responses (ABR) and auditory steady state responses (ASSR) using narrowband chirps (500, 100, 2000 and 4000 Hz) as the “gold standard” for diagnosis of hearing loss. Infants and children (n=102; 1 to 80 months of age) who failed newborn screening or had suspicion of hearing loss were seen in outpatient or surgical units for diagnostic audiology assessments. After informed consent and completion of IRB approved parent permission, children were assessed with threshold ABR and ASSR in randomized order. They also were tested with DPOAE (six f2 frequencies between 2000-8000 Hz), pure tone tympanometry (1000 Hz for age < 6 mo. and 226 for age >6 mo.) and wideband tympanometry on the same day in both ears. Results: A total of 165 ears were assessed with ABR, ASSR, tympanometry and DPOAE. Hearing level was classified as normal=94 (57%), slight=13 (8%), mild=23 (14%), moderate=12 (7%), and severe to profound=21 (13%). One case of possible auditory neuropathy was excluded (absent ABR and ASSR, normal DPOAE). Using recently published normative levels for infants, DPOAE had overall sensitivity of 96% and specificity of 81% for detection of slight or greater hearing level. Within the slight category, sensitivity was 70%, while it was 100% for mild and greater hearing levels. Area under the receiver-operator curve (AUC) was .88 to .95, depending on the DPOAE f2 frequency. For ears with normal hearing, wideband middle ear assessment was normal for 84% of ears. For ears with hearing loss, 55% had abnormal middle ear testing. Abnormal middle ear function was more frequent among the slight-mild categories than for moderate and greater categories. Conclusions: Using age-appropriate levels, DPOAE assessment is highly sensitive and specific for diagnosis of slight or greater hearing loss. In infants and children being assessed for possible hearing loss, abnormal middle ear function is prevalent and thus requires assessment using tympanometry and bone conduction ABR or ASSR. More research is needed that compares OAE and wideband tympanometry measures with bone conduction ABR and ASSR thresholds.

302 - Towards early identification of suprathreshold auditory deficits in infants and children
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Early Detection of Hearing Impairment (EDHI) programs have been highly successful in diagnosing hearing loss in infants and young children, allowing thousands of children to receive treatment at earlier ages. Detection of hearing loss in neonates and children who cannot reliably respond behaviorally is widely accomplished through the use of the Auditory Brainstem Response (ABR). While the ABR provides excellent information about hearing acuity, it is far less sensitive to suprathreshold deficits in neural encoding than other electrophysiologic measures, such as the frequency-following response (FFR). The ability to identify such deficits is crucial because they have been purported to influence language development and understanding speech in noise. Consistent with this view, low-amplitude FFRs are associated with language impairment and other developmental delays, while high-amplitude FFRs are observed in groups with expert auditory experience such as professional musicians and tonal language speakers.
Emerging work from several laboratories suggests that the FFR can be used in infants to detect suprathreshold developmental differences beyond the click-evoked ABR. In this talk we will review the recent data in this area demonstrating the associations between the FFR and developmental differences. We will also describe our recent work demonstrating a reversible effect of bilirubin on the FFR in neonates held in the neonatal intensive care unit (NICU). These data raise the possibility that suprathreshold deficits associated with other neonatal risk factors such as prematurity, hypoxia and cytomegalovirus may also be detected with the FFR. We also present preliminary data on follow-up measures of behavior in children with low FFR amplitude at birth and validation of a signal called a 'click plus' which can allow both ABR and FFR responses to be recorded simultaneously. Such work provides an important step to increase the feasibility of clinical recording of FFR, thereby allowing suprathreshold measures of auditory function to be widely assessed in neonates and young children.

296 - Resting state fMRI shows specific speech processing impairments in children with listening difficulty but normal audiograms
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Families of children attending audiology clinics report 'listening difficulty' (LiD), usually associated with hearing loss and multiple learning problems. For the ~5% of children without audiometric hearing loss (LiD_{NH}), most common concerns are 'school problems', developmental language delay (DLD), and attention deficit hyperactivity disorder (ADHD). DLD and ADHD are each reported in ~50% of children with LiD_{NH} we enrolled in a large, NIH-funded longitudinal study. Multi-faceted cognitive deficits were also found using the NIH Cognition Toolbox. Sub-clinical hearing loss (10 dBHL < PTA < 20dBHL; $PTA_{9\text{-}16kHz}$> 20dBHL) and reduced DPOAE were seen in some cases of LiD_{NH}, as well as in age-matched, typically developing children without LiD. We found little evidence of increased peripheral or brainstem dysfunction in the children with LiD_{NH}. Poor speech-in-noise intelligibility has a strong association with immature hearing and LiD, but only a weak association with specifically auditory processing. In contrast, resting state fMRI has revealed dramatically greater functional connectivity of cortical 'speech' areas in typical children than in children with LiD_{NH}, but no difference for 'non-speech' auditory areas. Children with primary ADHD had reduced connectivity re typical children for speech and, more so, for non-speech processing. Children within the LiD group who also had DLD had signifcant reductions in executive function connectivity. Children with autism spectrum disorder did not have reduced speech processing connectivity despite impaired speech-in-noise intelligibility. Current data suggest LiD_{NH} may be primarily a cortically-mediated problem characterized by a deficit in coding or retrieving speech/language in secondary auditory cortical areas of the temporal lobe and subsequent deficits in more rostral, cognitive modulation of speech hearing.
Key words: childhood learning difficulties, hidden hearing loss, auditory processing disorder

455 - Sensitized Monitoring for Aminoglycoside-Induced Hearing Loss in Neonates in Intensive Care
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Aminoglycoside therapy, typically gentamicin, is widely used in neonatal intensive care units (NICU) due to its targeted effectiveness to manage sepsis. However, in older children and adults it is well established that ototoxicity (hearing loss, balance deficits, tinnitus and/or difficulty understanding speech-in-noise) is a potential adverse effect of aminoglycoside therapy. Aminoglycoside-induced hearing loss begins in the higher frequencies (≥8,000 Hz) and can progress to lower frequencies over time with continued ototoxic exposure. Current newborn hearing screening protocols primarily use a two-stage approach to screen for auditory deficits. The transient evoked otoacoustic emission (TEOAE) test is used to screen for cochlear hair cell dysfunction and the click-evoked automated auditory brainstem response (AABR) test is used to detect neural deficits along the auditory pathway. Although the AABR and TEOAE tests are effective at identifying hearing loss in lower frequency regions (≤4,000 Hz), they are less sensitive to the status of higher frequency regions where aminoglycoside-induced damage initially occurs. Over the last decade, there have been technological advancements to enable the testing of higher frequencies using both ABR and distortion product (tone-evoked, DP) OAE tests. However, this technology has yet to be routinely implemented into universal newborn hearing screening programs. One reason for this is a lack of clinical investigation, as it is currently unclear whether infants exposed to aminoglycosides develop high-frequency hearing loss. Additionally, if they do develop aminoglycoside-induced hearing loss, it is unknown whether this is as dose-dependent as it is in older children or adults. Our prospective pilot study examined the effects of cumulative gentamicin exposure on hearing screening results when employing a traditional AABR test, and comparing those findings to a high-frequency DPOAE assessment (up to 10,031 Hz). Cumulative gentamicin exposure was calculated for each infant by quantifying the total daily dose based on body mass (mg/kg/day), as well as the total number of treatment days. We hypothesized that greater levels of cumulative gentamicin dosing would increase the likelihood of hearing screening referral for both AABR and DPOAE tests. Eighty-two infants (<37 weeks gestational age) from the Oregon Health & Science University (OHSU) NICU in Portland, OR were prospectively recruited. Parental consent was obtained prior to enrollment of all infants. Findings from this investigation showed a 5% referral rate for click-evoked AABR, a 39% referral rate for DPOAEs with a broad F2 range (2,063 Hz-10,031 Hz), a 29% referral rate for a low DPOAE F2 range (<4172 Hz), and a 44% referral rate for a high DPOAE F2 frequency range (>4172 Hz). In addition, there was a higher DPOAE referral rate for infants with >2 days of aminoglycoside dosing (p= 0.004) than there was for those with less aminoglycoside exposure. These data will be verified in a higher-powered multi-center study to identify patient and clinical risk factors associated with ototoxicity rates in NICU babies.
Key words: neonates, aminoglycosides, ototoxicity

295 - The association between speech-in-noise perception and extended high-frequency hearing
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People with clinically defined normal hearing frequently report difficulty hearing in noise. They often leave audiology clinics with no diagnosis to explain the difficulty they experience. Substantial evidence in adults and children demonstrate that extended high frequency (EHF; > 8 kHz) hearing, beyond the currently tested range of clinical audiometry, contributes to speech-in-noise (SIN) perception. However, the mechanisms underlying this association are not yet clear. Our preliminary data in children and adults with normal conventional audiograms, yet have difficulty understanding SIN suggests 3 hypotheses: 1) loss of audibility and/or broadened auditory filters at EHFs results in impaired SIN perception; 2) EHF hearing loss (EHFHL) is an indicator of damaged outer hair cells (e.g., reduced amplification or non-linearity) outside the EHF range of hearing that results in impaired SIN perception; and 3) factors causing hearing loss at EHFs may also cause deafferentation (e.g., loss of synapses, auditory nerve fibers and/or hair cells), resulting in impaired SIN performance. We reviewed data collected through multiple studies in our laboratory using standard (0.25-8 kHz) and EHF (9-16 kHz) audiometry, subjective reports of listening difficulties, digits-in-noise test, Bamford-Kowal-Bench (BKB)-SIN test, Listening-in-Spatialized-Noise task (LiSN-S), double-evoked TEOAEs with chirp stimuli (0.71-14.7 kHz), and Wideband Middle-Ear Muscle Reflex (MEMR) in children and adults (7-65 y/o;

N=344, updated results will be presented as participants continue to be enrolled). Results of these studies converge on 3 main findings: 1) EHFHL is a significant predictor of both subjective and behavioral measures of difficulty understanding SIN ($p<0.01$ to 0.001), suggesting that cochlear function in the EHF range may be an "early flag" for impaired SIN performance; 2) individuals with EHFHL had a mean elevation at standard frequencies of 3.8 dB ($p<0.001$). This elevation was significantly correlated with poor SIN performance ($r=0.32$, $p<0.001$), suggesting possible involvement of standard frequencies in impaired SIN perception despite normal conventional audiograms. Moreover, chirp-TEOAE revealed reduced SNR at standard frequencies in individuals with EHFHL relative to those with normal EHF hearing ($p=0.04$ to $p<0.01$). This finding suggests that EHFHL might reduce the necessary input for the proper functioning of mechanisms in cochlear regions corresponding to standard frequencies, resulting in impaired SIN performance. In addition, TEOAE-SNR for EHFs was a significantly better predictor of impaired SIN than pure-tone thresholds ($p<0.01$), suggesting that difficulty listening in noise might be related to damaged hair cell function that is not yet manifested in pure-tone thresholds; and 3) individuals with better EHF hearing displayed a steeper MEMR growth compared to individuals with poorer EHF thresholds ($r= -0.36$; $p<0.001$). Steeper MEMR growth was also significantly correlated with better LiSN-S scores ($r=0.20$, $p=0.006$). LiSN-S and EHF thresholds were also significantly correlated ($r=0.27$, $p<0.01$). These findings imply the possible involvement of synaptic or neural mechanisms in the impaired SIN perception observed in individuals with EHFHL. Overall outcomes of this study suggest multiple mechanisms at play in how EHFHL causes difficulties in SIN perception. Better understanding of the impact of EHFHL on auditory communication abilities of children and adults would motivate efforts to improve hearing conservation, rehabilitation and future treatment.
Keywords: Extended high-frequency, hearing loss, speech perception in noise

Lecture

471 - Triage in audiology – new incentives and new expressions of an old but pervasive idea

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Like tests for screening, triage tests must be simple and robust, to quickly determine patients' access to more elaborate assessment or treatment. Almost opposite to screening in its goal, triage is directed at evident pressing and cases; its output decision reserves the rare high-resource next stage for the most appropriate cases and is not about case-finding. Current pandemic pressures have enhanced the appreciation of the need for triage, via the dilemmas about which patients get access to particular scarce facilities (eg ICU), whether for Covid-19 or not, and there is increased population awareness of need for restrictions compared to past usual care. Triage is not primarily diagnosing cases, but sorting them; it distinguishes two onward pathways, usefully called 'advance or deflect', but its framework needs to offer something (eg advice, or alternative pathways) to those deflected. Proposals to specify a triage system need to be realistically focussed on nodes in pathways where it has the potential to be worthwhile, then the system has to be optimised and evaluated eg by health-economic comparisons of differing scenarios for sorting the case-mix at the node. In audiology, plausible nodes are seen in all problem areas.
This keynote lecture starts with instances of recent spread of triage approaches, then moves to an audiological illustration of inefficient practice at a node in an existing system This node should offer increased efficiency in matching audiology caseload needs to the facilities and personnel available. Such scrutiny can energise proposals for triage and the development of optimised short-from assessment within triage. For the two worked examples I draw on two large-study datasets on OM(E), posing and answering two main 'what-if?' research questions, essentially scenario modelling. There has to be a plausible criterion measure, usually more time-consuming than would be available or affordable in actual triage (that is the main point!). The triage formulation then requires prediction of this measure with useful accuracy by simple information, for example clinical appraisal and/or question items to patients/parents. The first application is on the large number of children with otitis media, mostly with effusion: (1) To delimit which of the children with provisional OM diagnosis most require allocation of resources to audiometry, can the hearing levels (HLs) be accurately enough predicted from tympanometry plus parental questions on hearing and OM, to leave actual audiometry to confirming exact levels only on cases above some severity criterion? This does not assume that HLs alone at one point of consultation necessarily have high predictive validity for cognitive development, behaviour or language that are of ultimate concern. However, HL is generally useful, and especially if complemented by measures of disease severity and duration. Secondly, (2) to assess extent of need, as complementary to the ability to benefit from treatment, is there a short set of clinical questions, which measures or predicts the developmental impact from OM(E)? Within example (2), the first stage, need, measured via impact, forms the simple pre-triage, leaving the more complex assessment of the ability to benefit to be applied only to the smaller triage-defined

subset, currently about 65-70% of sample. In evaluation, it has to be shown that the interposition of triaging at least does not seriously undermine the functioning of the next stage, and indeed that was shown for subsequent selection for ability to benefit from ventilation tubes in OME. The introduction of need as an independent consideration thus creates an ethically desirable 2-domain and 2-stage basis for recommending treatment (ie considering need plus ability to benefit).
An additional key provision enabling triage to deliver efficiency is a specified validation paradigm for gains at the node in question. For this, all assumptions should be explicit, eg that the criterion measure adopted for optimisation should quantify either the construct wanted in practice, or an acceptable surrogate (proxy) for it. Rigorous algorithms are intended to be applicable to the majority of cases. A short list of special case-types may also be needed to supplement general formulae. Productive direction of effort as the goal of triage is intensely practical, but its form benefits from intense science within a theoretical framework and attention to good measurement.

SPEECH PERCEPTION IN INFANTS

470 - Understanding the sound environments of babies and toddlers
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Background Hearing aids and cochlear implants allow deaf and hard of hearing babies to hear speech in quiet listening situations, but this becomes more challenging if speech is at a distance, there is background noise, or they are in a reverberant environment.
Typically developing infants have auditory access to a variety of soundscapes and experiences in the environment which help shape their 'world picture', supporting vital cognitive and sensory-motor development. Deaf and hard of hearing babies may miss out on sounds that are further away from them so they might lose opportunities to learn about what those sounds mean.
Remote microphone technology can help overcome issues in challenging listening environments and there is evidence to show that this technology is helpful for children from about 3-4 years old. There is increasing pressure in the UK context as elsewhere for radio aids to be provided at the time of first fit of amplification, within the earliest months of life. However, there is scant evidence about any potential drawbacks as well as perceived benefit of use with younger children, particularly for those aged under 18 months.
In our study, we have started to address these issues. We have developed an observational schedule in order to understand typical days and interactions for infants and families, by mapping everyday routine experiences. We have used this observational schedule with families with deaf/hard with hearing children and families with hearing children between the ages of 3 and 18 months. We will present descriptions and analysis of the soundscape to which infants are typically exposed and assess auditory access and environmental awareness or 'unawareness'.
We will use our findings to understand more about the sound environments of babies and toddlers, and to develop guidance for parents and professionals about appropriate use of remote microphone technologies with this age group.

50 - Consonant and Vowel Confusions in Well-Performing Children and Adolescents with Cochlear Implants, Measured by a Nonsense-Word Repetition Test

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Aims: The majority of early implanted, profoundly deaf children with cochlear implants (CIs) will develop correct pronunciation if they receive adequate oral language stimulation, and most of them obtain high scores on speech perception tests with sentences and monosyllables. In this study, we investigated to what extent they perceive minute details of speech.
The main aim was to measure the confusion of consonants and vowels in well-performing children and adolescents with CIs using a nonsense-word repetition test. The study also aimed to investigate how age at onset of severe to profound deafness influences perception.
Methods: The participating 36 children and adolescents with CIs (18 girls) had a mean (SD) age of 12 (3) years (range: 6–16 years). Twenty-nine of them were prelingually deaf and seven were postlingually deaf. Two reference groups of 17 normal-hearing (NH) 6-year-olds and 12 NH 13-year-olds were included.
Consonant and vowel perception was measured by repetition of 16 bisyllabic vowel-consonant-vowel nonsense-words and nine monosyllabic consonant-vowel-consonant nonsense-words in an open-set design. Two experienced phoneticians independently transcribed recordings of the participants' repetitions.
By choosing a nonsense-word repetition test, the perception of speech sounds was measured with only minor influence from top-down processing and decoding based on context. Furthermore, the load on working memory was minor, since only words with one or two syllables were included.
Results: For the participants with CIs, the mean (SD) consonant repetition score was 70% (8%). The consonants were mostly confused with other consonants with the same voicing and manner, and the voiced consonant repetition score, 64% (11%), was significantly lower than the mean (SD) unvoiced consonant score, 77% (9%). There was a devoicing bias for the stops; unvoiced stops were confused with other unvoiced stops and not with voiced stops, and voiced stops were confused with both unvoiced stops and other voiced stops. The mean (SD) vowel repetition score was 85% (11%). There was a bias in the confusions of [i:] and [y:]; [y:] was perceived as [i:] twice as often as [y:] was repeated correctly. Subgroup analyses showed no statistically significant differences between the consonant scores for pre- and postlingually deaf participants.
As expected, there were significantly fewer consonant and vowel confusions in the reference groups of NH children than in the groups of children with CIs. Common confusions for the 6-year-olds were [ŋ]-[m] and [y]-[i]. For the 13-year-olds, [ŋ] was often confused with [n] or [m], and [y] with [i]. In general, there were fewer consonant and vowel confusions for the 13-year-olds than for the 6-year-olds.
For the NH 6-year-olds, the mean (SD) correct consonant repetition score was 87% (6%) and the mean (SD) correct vowel repetition score was 89% (11%). For the NH 13-year-olds, the mean (SD) correct consonant repetition score was 94% (3%) and the mean (SD) correct vowel repetition score was 95% (6%). The mean (SD) voiced consonant score was significantly lower than the unvoiced consonant score [83% (8%) versus 92% (8%)] for the 6-year-olds, but not for the 13-year-olds [93% (4%) versus 97% (3%)].
Conclusions: The participants with CIs obtained scores close to ceiling on vowels and high scores on unvoiced consonants, but their perception was substantially lower for voiced consonants. This may partly be related to limitations in the CI technology such as insertion depth of the electrode and ability to convey temporal information for the transmission of low-frequency sounds.
The findings of this study show that many children with CIs have difficulties with perceiving minute details of speech and suggest that their perception capability is often poorer than their speech would indicate. Therefore, people they encounter in their everyday life might underestimate the severity of their hearing impairment. Nonsense-word repetition tests can enable clinicians and researchers to identify fine-grained speech perception difficulties, and use this information to improve speech therapy and CI technology.

115 - Role of Voice Cues for Speech-on-Speech Intelligibility in Children with Hearing Aids

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Background**:** In a crowded environment, understanding speech produced by one talker is closely linked to the ability to selectively listen to this specific talker among other speakers (speech on speech perception; SoS). Previous studies have shown that two fundamental voice characteristics are closely related to SoS intelligibility; fundamental frequency (F0), related to voice pitch, and vocal-tract length (VTL), related to the physical and perceived size of the speaker. Both of these acoustic cues have been shown to help differentiate the target speaker from masker speakers, enhancing SoS performance.
The purpose of the present study was to investigate if paediatric hearing aid (HA) users have additional difficulties in a competing-talker situation, compared to their normal hearing (NH) peers. Through systematic parametric manipulation of the masker voice, we could evaluate whether NH children and HA users benefit from F0 and VTL differences between target and masker talker in a similar way. And finally, we assessed whether target-to-masker ratio (TMR) affects SoS perception differentially for NH children than children using HAs.
Methods**:** The age range of inclusion for our participants is between 5 and 17 years. We have, so far, collected data from 63 NH and 20 bilateral HA user children, all native Turkish speakers. The test is based on the Children Coordinate Response Measure (CCRM), a computer-based subtest of the Perception of Indexical Cues in Kids and Adults (PICKA) test battery, developed at University Medical Center Groningen. The CCRM consists of target sentences, recorded by a female speaker, that contain a color and number combination. The masker consists of concatenated random segments of similar sentences uttered by the same speaker. The masker F0 was modified from the original voice in order to affect a pitch difference between target and masker (dF0; 0 and -12 semitones). Similarly, the VTL of the masker was artificially manipulated to affect a VTL lengthening (dVTL; 0 and 3.8 semitones). The TMR varied amongst: -6 dB (NH only), 0 dB, 6 dB, and 12 dB (HA only). Finally, intelligibility was also measured for target sentences presented without masker. Each condition was repeated 7 times, yielding altogether 91 trials in total. The masker started first, shortly after followed by the target, and the participants were instructed to report the color and number they heard in target sentence by pressing the corresponding button on the screen.
Results**:** Our results showed that the average SoS performance improves steadily with age. The preliminary data with HA user children indicated that NH children had better overall SoS intelligibility scores than HA user children for all conditions. However, the age effect in HA children could be similar to that in NH but this will have to be confirmed after more data is collected.
When results are examined in terms of voice cues differences, preliminary results showed both NH and HA-user groups' lowest scores were observed when there was no voice difference between target and masker sentences, i.e., both dF0 and dVTL were 0 st. Both NH and HA children's SoS intelligibility scores increased with the target and masker voices becoming more different from each other.
NH children took advantage on F0 decrease and VTL increase through all TMR conditions. The HA group seems to also benefit from F0 and VTL differences, but higher TMR (12 dB) did not seem to yield better intelligibility compared to lower TMR (6 dB).
Conclusion**:** This study has shown that speech comprehension in presence of a competing talker could be a challenge for children with HAs compared to their NH peers. It is to be seen, however, if SoS perception improves with age in HA user children, similar to NH children.
SoS intelligibility scores measured as a function of systematically changing dF0 and dVTL values between the target and masker speakers showed that changing voice cues had a positive effect on SoS. NH and HA-user children seemed to both benefit from voice differences in a similar manner but not to the same degree, which could prove detrimental for HA users in real-life situations. Further analysis will be performed as more data is collected.
Keywords: Speech on speech intelligibility, hearing aids

198 - Speech-in-noise identification performance in children with hearing impairment with cochlear implants and hearing aids: Three-year longitudinal study with comparison with children with normal hearing

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Introduction**:** The introduction of universal neonatal hearing screening, as well as advanced hearing aids (HA) and cochlear implants (CI) for paediatric populations, has reduced the impact of congenital hearing impairment (HI) on children, their families, and society at large. It has been documented that early intervention with HA fitting by three months of age and enrolment in family-centered auditory-verbal intervention by six months of age allow children to close the language gap and develop age equivalent language by three years of age. However, clinical experience has shown that even short periods of sensory deprivation can have a profound and permanent effect on the development on the entire central auditory system and can cascade to other spheres of functioning such as language and cognition. Therefore, it is important to keep monitoring paediatric populations with HI on all aspects of development. School-aged children with HI listen and learn in noisy environments. Therefore, ongoing monitoring of speech understanding in noise is essential to investigate whether intervention and rehabilitation is adequate. The present study is part of a national four-year project in Denmark, "IHEAR – in school with hearing impairment". The vision of the project is to leave no child with HI behind. This vision includes hearing, listening, speech, language, cognition, and social well-being outcomes.
Methods**:** The aim of this study was to assess the performance of a paediatric population with the Dantale II, a Danish sentence-based test of speech understanding in noise. The secondary aims were to identify similarities and differences between groups of children with HI and normal hearing acuity (NH) and between different hearing technologies, to monitor the evolution of performance over a period of three years, and to investigate possible associations between speech perception and verbal working memory.
This was a longitudinal, prospective study comparing groups of children. A total of 70 preschool/school-aged children aged 4–10 years were included in the study (n = 46 with HI and n = 24 with NH). Children with HI used hearing technology from various manufactures (n = 32 with CI and n = 14 with HA). All children with HI had benefited from early identification, early treatment, and three years of intensive auditory-verbal therapy prior to enrolment.
The Dantale II includes five-word sentences. Each sentence has the same syntactical structure: name, verb, numeral, adjective, and object. The sentences have no semantic cues, which provides a low probability and a high reliability. The test is sensitive using an adaptive procedure and the result is expressed as signal-to-noise ratio (SNR) where 50% of words are correctly identified. Test procedure included 1) Training part 1: 10 sentences without noise; 2) Training part 2: 20 sentences with adaptive noise as in test; 3) Test part 1: 20 sentences with adaptive noise, and; 4) Test part 2: 20 sentences with adaptive noise. Verbal working memory was assessed with the Clinical Evaluation of Language Functioning-4.
Results**:** The rate of Dantale II completion varied according to age and hearing status. Dantale II seems clinically feasible from the age of approximately six years. Children with NH outperformed children with HI both on ability to complete the test and in their test scores. The scores of children with HA were significantly better than those of children with CI. Annual testing over three years showed performance improvement over time. A significant and moderately strong association between speech understanding in noise and verbal working memory was identified.
Conclusions: This study shows how a test of sentence perception in noise can be used to track the development of children with HI and the performance of their hearing devices. Whilst a significant association between speech perception and verbal working memory was identified, the causal pathway remains unclear. Future research on cognitive development of children with HI is essential.

398 - Spatial release from masking in school-aged children with cochlear implants and hearing aids and comparison with children with normal hearing acuity

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Introduction**:** Language and speech development in children depends on access to acoustic speech signals. When fitted at an early age, hearing devices can greatly compensate for hearing impairment (HI). Still, speech understanding can be challenging for children with hearing impairment when exposed to complex listening situations, typically in which the speech signal is accompanied by competing signals. In such listening situations, children often exhibit a benefit in speech understanding when the target speech is spatially separated from the masking signal. This phenomenon is usually referred to as spatial release from masking (SRM). Here, we investigated SRM in children with HI and with normal hearing (NH). This study is part of the four-year research project IHEAR, which sought optimal development of Danish school-aged children with HI.
Methods**:** Speech reception thresholds (SRT) were tested in 28 children with cochlear implants (mean age = 8.7 years, age range = 6.1 – 11.4 years), 10 children with hearing aids (mean age = 8.6 years, age range = 6.9 – 10.4 years), and 16 children with NH (mean age = 9.8 years, age range = 6.5 – 12.5 years). All children with HI were of school age and underwent three years of auditory verbal therapy as part of an intervention program. Two conditions were assessed, a baseline configuration in which target speech and noise were spatially collocated, and a spatial configuration with separate speech and masking noise. The test material was the Dantale II speech test, a matrix material consisting of lists, each with ten five-word sentences with the same syntactical structure (name + verb + numeral + adjective + object). The masking noise was unmodulated speech-shaped noise, which was presented either collocated (speech and masking at 0°) or spatially separated (speech at 0° and masking noise at 180°). Hearing device settings were not adjusted: they were used under the same conditions as in daily life. Audiological and demographic information was collected for each child. Multiple regression analyses were performed to investigate the association between SRM and a range of predictors.
Results**:** The results indicated an improvement in SRT for the spatial condition compared to the collocated condition for children with HI and children with NH. In bivariate analyses, children with hearing aids performed no differently than children with NH, but children with cochlear implants performed less well. Regression analyses showed that this trend was influenced by individual differences and demographic factors such as age and the presence of additional disabilities.
Conclusion**:** This study indicates that the early intervention in children with HI can result in SRM levels comparable to those of their normal-hearing peers.

435 - Development of social-pragmatic understanding in children with congenital hearing loss between the ages of 4 and 6 years

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Introduction**:** Social-pragmatic skills are known to be associated with self-image, peer relationships, and academic outcome. Previous studies have indicated that despite early diagnosis, hearing loss (HL) still may affect communicative development in many ways, including the social-pragmatic development. However, the previous research on the communication skills of children with HL has focused mostly on speech production and linguistic skills, and there are only a few studies published on the social-pragmatic development of children with HL. The aim of this study was to find out, how social-pragmatic understanding develops in children with congenital HL who have received their hearing aids (HAs) and cochlear implants (CIs) at an early age.
Methods**:** The participants were 15 children with bilateral HAs, 15 children with bilateral CIs, and 30 children with normal hearing (NH). The children were assessed at the chronological ages of four, five and six years with the Pragma Test, which is a research based and standardized method used widely in Finland. This test includes 39 questions that require understanding implied meanings of utterances. The children are also asked to explain their right answers to elicit their possible awareness of the inference processes.
Results**:** All the groups of children showed significant development in their social-pragmatic understanding between the ages of 4 and 6 years. However, the children with bilateral HAs, and with bilateral CIs showed

significantly poorer performance compared to the children with NH at the ages of four, five and six years. Still at the age of six years, more than half of the children with HL performed below the 10th percentile in the Finnish normative sample of the Pragma test.
Conclusions**:** Early diagnosis did not necessarily prevent problems in social-pragmatic development. Thus, social-pragmatic aspect of communication should be paid attention in clinical work. For better clinical practice, it would be essential to find out, which areas in social-pragmatic development are affected, and how different background factors (e.g., age of amplification/ implantation, socio-economic factors, linguistic skills) correlate with social-pragmatic development of children with HL. Furthermore, there is a need to find out, whether the low-performing children with HL will catch up with their peers with NH at some later stage of development.

SPEECH PERCEPTION

157 - Fully Automated Speech Comprehension Measures: comparing methods for precision and efficiency

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Background: Several accurate fully-automated assessments of speech comprehension have been validated in applied psycholinguistics. Rapid advances in spoken language processing over the past 15 years have enabled development of such tests in several major languages, and many can return reliable results in a 5- or 10-minute self-administration. (e.g. Bernstein, VanMoere, Cheng 2010) It may be time to consider adapting some of these methods and technologies to large-scale hearing screening or to diagnostic hearing assessment, keeping in mind their close relation to SPIN (e.g. Kalikow, Stevens, Elliott 1977) and HINT (Nilssen, Soli, Sullivan 1994). The goal is to understand the different available automated measures of speech comprehension to identify new and promising tests at the intersection of precision, efficiency, simplicity, and client acceptance. The measures under study are most closely related to communication, but they may find application in diagnosis and prescription. Research Aims: We measure the accuracy and inter-relations among several automated listening measures (1) to determine which are most closely predictive of communication performance, and (2) to determine which are most efficient, most accurate in scoring, and most acceptable to participants. Method: As part of a larger pilot/validation study of an educational assessment, 430 normal hearing participants across nine locations self-administered four non-adaptive, automated listening tests, in each of which spoken materials were presented and participants responded by speaking. All four tests were fully automated: instructions, timing, scoring, and reporting were all done in real-time by computer. First was a YesNo test (16 sentences, respond yes or no, 3 minutes duration). Second was a Fill-In or Cloze test (16 items, say the missing word, 4 minutes). Third was a SentenceRepeat test (16 items, repeat verbatim, 4 minutes). Fourth was a ListenRetell test (3 spoken narrative items, retell in own words, 5 minutes). Of the 430 participants, 69 also took the Oxford Online Placement Test which has a separately scored listening section (15 adaptive spoken-dialog items, select from four written answers to a written question, 25 minutes). Participants (ages 16-78, average 28) were tested in groups on available computers in a variety of relatively uncontrolled acoustic environments, using inexpensive “gaming” headsets with boom microphones (e.g. HyperX Stinger). Results: Among the four automated tests, participants most preferred the ListenRetell (with fewer, longer items) and a plurality did not like the Fill-In (Cloze) test. Assuming that each test provides relatively independent information about listening ability, correlation of each test to the average of the other three tests is a measure of the test score quality. Under this the Fill-In test performs best r=0.86, then SentenceRepeat r=0.83, ListenRetell r=0.78, and YesNo r=0.68. In relation to the more traditional multiple-choice Oxford listening test, the SentenceRepeat has the highest correlation r=0.72, then Fill-In r=0.67, ListenRetell r=0.67, and YesNo r=0.35. Further psychometric analysis will be presented in the paper.
Discussion: Results suggest that fully automated, self-administered listening tests may be able to measure speech reception with accuracy comparable to longer, adaptive tests. For example, measurement of speech comprehension by automatic scoring of free-form spoken retellings correlates with human judgments of comprehension from the spoken retellings with r=0.91, and scores from a fixed pilot form of a 5 minute test that participants enjoy shares nearly half the variance with a much longer and well-calibrated adaptive listening test. There may be a useful place for such low-cost, real-time tests in large-scale hearing screening.

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Key words: assessment, listening, psychometrics, screening.

467 - Revisiting the notion of "context" in aging and real-time spoken language processing

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Background**.** The comprehension of speech involves an array of unconscious processes including the analysis of individual speech sounds, word recognition, syntactic analysis, semantic interpretation, and identifying the communicative intent of the speaker. Although classical models of mental architecture conceived of these subtasks as serial stages in processing, contemporary evidence shows they occur in parallel and with great immediacy, affecting interpretation even before a word is heard in its entirety. The evidence also shows that rapid real-time processing is strongly tied to the spontaneous and unconscious use of contextual cues. This latter observation has important consequences for our theoretical frameworks. Specifically, it has often been suggested that age-related declines in sensory or cognitive processing can be offset by using context in a compensatory way. But if younger adults are already routinely drawing on context during speech processing, is the "compensatory" use of contextual cues still a meaningful concept? Moreover, certain kinds of contextual cues are not readily available, but instead require in-the-moment processing that could itself be subject to age-related cognitive declines. If so, the idea that contextual cues will routinely help speech processing might be overstated. Current focus**.** A range of studies from our laboratory provide empirical insights on these issues by exploring how qualitatively different types of contextual factors influence real-time comprehension in younger (undergraduates) and older adults (65+). In the experiments, listeners follow instructions related to depicted objects on a computer screen, and gaze position is tracked at the millisecond level. The pattern and timing of eye movements reveals listeners' incremental interpretation as words are encountered in real time. Hearing and vision abilities are controlled for via screening procedures. A subset of these studies are discussed here. One set of studies explores listeners' ability to use various kinds of information encountered earlier in a sentence to guide real-time processing. Consistent with earlier findings, our evidence shows older adults readily draw on the meanings of previously-heard words to guide expectations for what will be said next, and do so in the same way as younger adults. Further, we found that older adults can draw on even more subtle kinds of cues in the unfolding sentence. Past research has shown that hearing an "um" or "uh" (as in "Now, click on the, uh, clock") leads listeners to rapidly shift their gaze toward objects that have not yet been mentioned by the speaker (anticipating reference to those objects). This reflects the fact that speakers tend to be more disfluent when producing a "new" description due to lexical access demands in language production. Our experimental results demonstrated the same sensitivity in older adults. Collectively, this set of studies shows comparable performance by younger and older adults at using contextual cues carried by the auditory signal. A second set of studies explores listeners ability to draw on contextual cues that are part of the broader communicative scenario. Consider, for example, a physical setup where certain objects that are visible to the listener are unknown to the speaker because they are not visible from the speaker's viewpoint (because they are blocked from view by some opaque barrier). In this case, a listener should expect that the speaker will NOT be referring to those objects (e.g., when providing an instruction like "Point to the [X]"). In contrast to the first set of studies, eye measures here showed poorer performance in older adults: Older listeners had more difficulty restricting attention to only mutually-visible objects as the instruction unfolded. The more complicated nature of the contextual cues in this case (i.e., they are not provided "for free" in an earlier part of an unfolding sentence) apparently makes them more difficult for older adults to spontaneously use in the course of real-time comprehension. Summary. The results demonstrate that certain contextual cues are readily used by older adults during real-time language processing. Importantly, however, these cues are also used by younger adults. Indeed, in this case, no differences are found across age groups. This provides a more nuanced perspective on what older adults' compensatory use of context could possible mean: If contextual cues are already routinely used in early adulthood, the way they can eventually offset effects of sensory decline is not likely to reflect any kind of conscious or deliberate shift in listening strategy. However, our results also show that other kinds of contextual cues are not readily used by older adults. In these cases, the cues are external to the speech stream, requiring a different kind of in-the-moment communicative sensitivity. Together, the findings clearly demonstrate that "context" cannot be treated as a single undifferentiated construct, and that more caution may be needed in hypotheses about its role in supporting older adults' language processing.

385 - Not only speech in noise. Hearing loss and the perception of fast speech
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Background and aims**:** The most frequent complaints of older adults with hearing impairment are when listening to speech in adverse situations, mainly in the presence of competing speech and when speech is fast. A combination of hearing acuity, auditory processes and cognitive skills were mentioned as factors accounting for the difficulties in processing speech in noise. Reduced auditory processing and cognitive factors, but not hearing acuity, were mentioned as factors involved in the perception of fast speech. We explored factors that account for the difficulties in perceiving both speech in noise and fast speech.
Method**:** Two studies were conducted, with 55 young adults and 46 older adults in the first study, and 70 older adults in the second. Younger participants had normal hearing, and the older groups had various degrees of hearing loss. The participants were required to identify speech (sentences, 5-6 words long) presented in 3 modes: speech presented with multi talker babble noise (younger participants in study 1, all participants in study 2), time compressed and natural fast speech (all groups in both studies). In addition, cognitive factors (working memory, vocabulary, attention) and rapid perceptual learning were also evaluated. Mixed models were used to quantify the relative contribution of hearing acuity and cognitive factors on the perception of the speech samples.
Results**:** In both studies, hearing acuity was the strongest predictor for the identification of both speech in noise and rapid speech, even after accounting for all the other tested factors. Other factors differently emerged across the studies and speech tasks, and included age, baselines perception of time compressed speech, vocabulary and rapid perceptual learning.
Discussion**:** Hearing acuity accounts not only for the perception of speech in noise, but also for the perception of fast speech. In future work, we intend to study whether acclimatization to hearing aids in new users is accompanied by improved identification of fast speech.

130 - Degradation of speech perception with competing speakers
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Understanding speech when several people are talking at the same time (commonly referred to as the cocktail party scenario) is a relatively difficult task. For people with hearing impairment the cocktail party scenario is even more demanding than for normal-hearing listeners. This task is made easier if the voice of interest differs from those of the competing talkers. When the target speaker is much louder than the competing speakers (a favorable signal-to-noise ratio, SNR), naturally he or she is more easily understood. In addition, phrases spoken by different-sex talkers are more easily segregated than those spoken by same-sex talkers.
The voice of every speaker has two main characteristics: the fundamental frequency, *F0*, which is determined by the anatomy of the vocal cords, and the vocal-tract length, *VTL*, which is determined by the anatomy of the vocal-tract resonance cavities. These two properties determine the size, gender and age that listeners attribute to a speaker. Differences in these vocal characteristics have been shown to be important segregation cues.
As we grow older our hearing degenerates as does our ability to understand speech on speech. This decline has two causes: hearing loss and possible age-related cognitive decline. The research described in this paper is part of a larger study in which, for the first time, these two causes are disentangled.
As a first step we have explored the full relevant *F0-VTL-SNR* space for young normal hearing adults (8 males, 8 females). We have used the Coordinate Response Measure (CRM) matrix test, where the *F0* and *VTL* of the competing voice was altered and the characteristics of the target voice were kept unchanged. In addition, the intensities of both voices were altered in such a way that their combined level remained constant.
In a second experiment, we have used a similar test in young normal hearing adults, as well as older adults with nearly normal hearing and older adults with mild-to-moderate hearing loss, in order to unravel the contributions of age-related hearing loss and age-related cognitive decline on deterioration of our ability to understand speech on speech. In this second experiment, we have explored a range of the *F0-VTL-SNR* space comparable to that of the first experiment. Keeping the *F0*, *VTL* and loudness of the target voice constant, we altered those of the competing voice. We will report the findings of these two experiments and show how voice differences affect speech perception with competing speakers in young normal hearing adults and in older adults with and without hearing loss.

264 - Validation of a Spanish lists of words spoken corpora generated and comparison of perfomances with non-spoken corpora generated lists of words

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Hernández y Mora 2013 Spanish Lists of Disyllabic Words (HMWL-2013) were validated through a large and facts variated population across five years lapse (2014-2019). The ten lists of twenty words each one, had been developed from a large spoken corpora of twenty-four adults, Venezuelan Spanish talkers. Initially validated by their intrinsic features, it was decided to validate in diverse groups of people and also to compare the results obtained with the application of these lists to the obtained with oldest lists from other, which had been created from non-spoken corpora (NSC-WL). The facts evaluated comparing performance in speech recognition on six hundred eighty-four (684) normal hearing subjects were age; sex; level of education; normal or mild-loss hearing level. The performances were measured in two ways: i) accounting the word errors and ii) accounting the phoneme errors. All these facts are analyzed using the Wilcoxon test (for multiple dependent samples, paired per subject), with a significance level of 5% (p-value ≤ 0.05). The results show a better performance with HMWL-2013 for age, level of education, and level of hearing when has been compared with the performance with a NSC-WL. The results were independent of normal o mild loss hearing but there was a difference if it was accounting as word errors or individual phoneme errors. In conclusion, spoken corpora originated would be preferred to non-spoken corpora obtained word lists because it would reflect better performances more likely to real daily life conversations.
Keywords: Speech audiometry- words lists- spoken corpora

220 - Speech-likeness and binaural parameters in everyday-life recordings: implications for clinical audiology

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Introduction In clinical audiology, participation in social interactions is an important priority for listeners with impaired hearing; hence, an important goal is to optimize auditory function in multiple-source environments. Speech recognition in these environments is a major component of auditory function in the context of social interactions, and a lot of research has been done in this area, including the role of binaural processing in environments with multiple sources and/or reverberation. In the research reported here, bilateral acoustic signals in a number of realistic environments were recorded and analysed. The analysis of these bilateral stimuli, the “bilateral vibration pattern”, allows us to investigate the nature of the information that is available to the binaural hearing system in realistic scenarios.
Method Acoustic recordings were made in multiple natural environments, which were chosen to be similar to those reported to be difficult for listeners with impaired hearing. These environments include natural conversations that take place in the presence of other sound sources as found in restaurants, walking or biking in the city, etc. Sounds from these environments were recorded binaurally with in-the-ear microphones and were analyzed with respect to speech-likeness measures and with respect to interaural differences. The speech-likeness measures were based on amplitude-modulation patterns within frequency bands and were estimated for one-second time-slices. The binaural measures included interaural coherence, interaural time difference, and interaural level difference, which were estimated for time-slices of 20-ms duration. Binaural measures were documented for 1/4-octave frequency bands centered at 500 Hz and for the envelopes of 1/4-octave bands at 2000 Hz. For comparison purposes, the same speech-likeness and binaural measures were computed for a set of virtual recordings that mimic typical clinical test configurations. These virtual recordings were created by filtering anechoic waveforms with available head-related transfer functions (HRTFs) and then combining them to create multiple source combinations.
Results and Clinical Implications Overall, the speech-likeness results show large variability within and between environments and also a significant fraction of time-slices with a single good ear. Further, the interaural parameter results show that the natural recordings contain a relatively small proportion of time-slices with high coherence compared to the virtual recordings. So, the information available to the binaural hearing system in realistic scenario’s is sparse. The normal auditory-cognitive system can function adequately in the majority of environments; however, in cases of auditory impairment and/or reduced top-down resources, everyday life is a challenging condition.

The significant fraction of time-slices with a single good ear as measured by speech-likeness suggests that the better-ear effect is relevant for daily functioning, which supports the prescription of bilateral amplification for appropriate candidates. This also supports the notion that patients miss substantial information if they do not have the use of two ears (e.g., because of unilateral deafness).
For individuals with impaired hearing, our analyses also suggest that everyday environments contain relatively high numbers of time-slices in which neither ear receives adequate speech-likeness. This situation may improve with bilateral amplification, but in many cases advanced signal-processing schemes or remote microphones would be needed to enhance the SNR (and hence the speech-likeness) to achieve good intelligibility. Furthermore, restoring/rehabilitating binaural function is important. This study shows that, even in situations with low interaural coherence, there is relevant binaural information in realistic stimuli for the localization and separation of sources. This information should be processed and transferred optimally to the auditory system. Listeners with impaired hearing should be trained to optimally make use of these cues, and hearing-assist devices should be designed to maintain these cues.
Finally, there are implications for clinical tests to assess speech recognition capacity. These tests typically use well-defined setting with highly coherent stimuli, like the virtual recording with female target speech and male masker in the current study. These tests usually target the condition of just-intelligible speech at negative Target-Masker-Ratios. The current study shows that such tests are only partly representative for daily life and that there is broad scope for ecologically valid tests. Such tests should not necessarily mimic realistic configurations, but merely include more temporal dynamics in speech-likeness values and in interaural parameters and also less coherent stimuli.

AUTISM SPECTRUM DISORDERS

386 - Cochlear Implantation of Children with Autism Spectrum Disorder: Impact and Long-term Results

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Introduction: The incidence of autism spectrum disorder (ASD), a developmental disorder associated with congenital CMV and other conditions associated with hearing loss, is increasing. Knowledge of the range of outcome and benefits of cochlear implantation for children with ASD is essential for parental counseling, planning of habilitation and educational support.
Methods: Children with ASD who underwent CI at a tertiary care children's hospital between 1991-2018 were retrospectively reviewed, and surveys were sent to parents. Main outcome measures included speech perception, expressive communication mode, educational placement, social engagement, consistency of CI use, and parent survey of child behavior change.
Results: Thirty children implanted between 1991 and 2018 diagnosed with ASD were identified. Mean age at CI was 3.5 years (0.8-11.8), mean age at diagnosis of ASD was 5.1 years (2.0-15.0) and mean follow-up was 10.5 years (1.4-21.6). Twenty two of thirty children (73%) were diagnosed with ASD after CI. Thirty-three per cent of all and 45% of the 22 consistent device users developed measurable open-set speech perception after 4.5 years of device use. Educational placement at last follow-up was: 13% mainstreamed without interpreter, 50% special education, 23% total communication program, 10% therapeutic residential or day school, and one home schooled. Spoken language alone was used by 31% and spoken plus sign by 14%, with the remainder using sign alone, augmentative communication devices or no mode of communication other than some natural gesture. By parent report, 86% showed improvement in social engagement compared to pre-CI.
Conclusions: Findings support a growing body of literature that cochlear implantation may improve auditory skills, language and enhance social engagement in deaf children with ASD. The differential diagnosis of lack of expected progress after CI should include consideration of ASD as a co-occurring condition.

484 - Sensory gating of autism spectrum disorder (ASD) children using Auditory Brainstem Response (ABR) with Counting-digit Stroop task: A pre-liminary study

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Background**:** Auditory sensory gating has been explored in many of the past studies with using P50 sensory gating test. In few recent publications, the influence of top-down cognitive inhibition through sensory gating pathway on the ABR findings has been reported. These studies, however, were conducted only to normal hearing adult with lack of attention to subject with brain disorder such as autism spectrum disorder (ASD). Thus, the present study aims to investigate the auditory sensory gating of ASD children using auditory brainstem response (ABR) conducted concurrently with psychological task namely counting-digit Stroop task.
Methods**:** Ten ASD children age between 6 and 12 years old with normal hearing were recruited. The ABRs test were conducted while participant performing counting-digit Stroop task in four test conditions, (i) baseline (no task), (ii) incongruent, (iii) congruent and (iv) neutral. Each task condition has 60 trials and the ABR was stopped until the child completed each trial. Repeated measure ANOVA was used to compare the ABR wave V amplitudes and latencies, Stroop task response times and percentage of correct responses among all test conditions. Additionally, Pearson correlation coefficient was used to measure the relationship between ABR cognitive inhibition and Stroop interference effect. The ABR cognitive inhibition was calculated by subtracting the ABR wave V amplitude from Stroop neutral with incongruent test conditions; the Stroop interference effect was obtained from the differences in the ABR wave V amplitude between incongruent and neutral test condition for both response times and correct responses.
Results**:** The ABR wave V amplitude was not statistically different across Stroop task conditions ($p>0.05$) which suggest no significant influence of cognitive inhibition to the ABR wave V amplitude in ASD children. Significant influence of cognitive interference on response times and correct responses was found across test conditions ($p<0.05$). Higher cognitive interference from incongruent trials resulted to increase in response times and reduction in the percentage of correct response as compared to the trials without cognitive interference (congruent and neutral). In addition, no significant relationship was found in the ABR sensory gating and Stroop interference($p<0.05$).
Conclusion**:** Our pre-liminary data showed that the ABR wave V amplitude did not change with increased cognitive load in all task condition among ASD children.
Keywords: ABR, sensory gating, autism, cognitive interference, response time
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Lecture

434 - Hearing and vision health for people with dementia in residential long-term care: Knowledge, attitudes and practice in England, South Korea, India, Greece, Indonesia and Australia

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Background Up to 90% of people with dementia in long term care (LTC) have hearing and/or vision impairment. Hearing/vision difficulties are frequently under-recognised or incompletely managed. The impacts of hearing/vision impairment include more rapid cognitive decline, behavioural disturbances, reduced quality of life, and greater care burden. This research investigated LTC staff knowledge, attitudes and practice regarding hearing/vision care needs for residents with dementia.
Methods A survey of staff in LTC facilities in England, South Korea, India, Greece, Indonesia and Australia. Respondents used a five-point scale to indicate agreement or YES/NO response to questions regarding sensory-cognitive care knowledge (what is known); attitudes (what is thought); practice (what is done).
Results Respondents reported high awareness of hearing/vision care needs, although awareness of how to identify hearing/vison difficulties or refer for assessment was low. Most felt that residents were not able to use hearing/vision devices effectively due to poor fit, being poorly tolerated or lost or broken devices. A substantial minority of respondents reported low confidence in supporting use of assistive hearing/vision devices, with lack of training the main reason. Most staff did not undertake routine checking of hearing/vision devices, and it was rare for facilities to have designated staff responsible for sensory needs. Variation among countries was not significant after accounting for staff experience and having received dementia training.
Conclusions There is a need to improve sensory support for people with dementia in LTC facilities internationally. Practice guidelines and training to enhance sensory-cognitive knowledge, attitudes and practice in professional care teams is called for.
Key words: hearing care, vision care, dementia, LTC, staff training, KAP survey, nursing home

Technology Update

382 - Hearing Aid Technology to Support Communication, Learning, and Inclusion for Children and Teens

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Oticon's Pediatric BrainHearing philosophy and innovative sound processing strategies in Oticon hearing technology provide a strong communication network to support the hearing needs of children and teens with hearing loss. With a deep neural network embedded on the new Polaris platform and advanced features,

important sounds are delivered with exceptional resolution. This presentation will discuss research on how new hearing aid technology and how it supports full access to sound and communication.

245 - Examining speech recognition with the use of adaptive gain receivers and ReSound Multi Microphone technology

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Introduction The benefits of hearing assistive technologies (HAT) are well documented in today's literature. They are applicable for not only children and adults with hearing loss, but also those with auditory processing deficits, learning disability, auditory neuropathy spectrum disorder, language and attention deficits, as well as English language learners and those who hear within normal limits (American Academy of Audiology, 2008). The benefits of HATs are intuitive: improvement of the Signal-to-Noise (SNR) by placing a microphone closer to the target of interest and sending that audio input directly to the user's hearing devices. This can improve the individual's speech perception and discrimination in noise, speech understanding at a distance, as well as improve performance and attention in school. The most commonly used HAT devices include frequency modulated (FM) and digitally modulated (DM) wireless remote microphone systems. The ReSound Multi Mic is a unique wireless microphone solution that meets the needs of its users as well as offering an affordable solution for all. What makes the Multi Mic solution flexible and cost effective is its true compatibility with HATs from other industry manufacturers, all while maintaining a proven adaptive gain advantage. This project compliments a previous investigation that studied the ReSound Multi Mic's behavior when used in tandem with digital modulation (DM) technology. The project: An innovative and cost-effective approach to wireless remote microphones (Quilter and Wright; 2017), discussed and confirmed the preservation of the adaptive gain benefits of DM receivers when coupled to the ReSound Multi Microphone. However, there have been no studies that examined speech recognition obtained with the use of adaptive gain receivers coupled directly to hearing aids versus an adaptive gain receiver coupled to the Multi Mic. The intention of this study is to explore and confirm that patient speech recognition scores obtained with the use of adaptive gain receivers coupled to the Multi Microphone, remain uncompromised between the two technologies.
Methods In this randomized, double-blind study, subjects are fit with ReSound Quattro receiver in the ear hearing aids. Recorded speech recognition scores in noise are obtained in the following conditions: 1) hearing aid only, 2) Digital modulated receivers connected to the hearing aids via direct audio input, 3) digital modulated receivers connected to the hearing aids via multi microphone and 4) multi microphone only.
Research Goals and Objectives Examine speech recognition scores obtained with the use of adaptive gain receivers coupled to ReSound Multi Microphone

1. Promote access to speech and language using cost effective measures
2. Instill confidence in audiologists when fitting two different technologies.

Preliminary results Preliminary results are positive at the date of this submission. Previous investigation has confirmed electro-acoustically the two technologies work in tandem with positive outcomes. Trending suggests patient's speech recognition scores with two technologies will not be compromised and cost-effective solutions will be confirmed.

EPIDEMIOLOGY

349 - Long-term hearing decline in the workplace: A longitudinal population study

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Objectives**:** Hearing loss due to exposures at work, particularly noise, is a worldwide problem. As there are few large long-term studies on this topic, we aimed to determine the 20-year hearing decline in different occupations in a large study population.

Methods**:** We used data from The HUNT Study, a population-based health study in Norway, to create a longitudinal study with audiometric measurements 20 years apart (1998-2018). Yearly registrations on occupation were collected from Statistics Norway. The association between hearing decline, within frequencies which are typically studied in relation to noise-induced hearing loss (3000-6000 Hz), and occupation was evaluated by using multiple linear regression models, adjusted for age, sex, leisure noise, smoking history, previous ear infections and otoscopy findings. Clerks were used as reference category, due to anticipated low noise exposure at work and a sufficient number of participants in strata of sex and age groups.
Results**:** The study comprised a total of 12,086 individuals, of which 57 % were women. Men were on average 64.6 ± 10.9 years old at the end of the study and had a mean hearing decline (at 3000-6000 Hz) of 20.1 ± 12.3 dB during the 20-year study period. Women were on average 63.5 ± 11.1 years and had an equivalent mean hearing decline of 15.8 ± 12.1 dB. Compared to the reference group (clerks), the 20-year hearing decline was larger in some occupations: For men, “other craft and related trades workers” (food preparers, wood treaters, etc) had a 4.6 dB larger hearing decline and “building frame and related workers” had a 3.6 dB larger hearing decline during the study period. Among women, the differences between clerks and other occupations were smaller. In the older age group (63+ years at endpoint), “other craft and related trades workers” had a 6.4 dB larger hearing decline than clerks, and in the younger age group (below 63 years at endpoint), “building frame and related workers” had a 2.9 dB larger hearing decline.
Conclusions**:** Our study indicates a larger 20-year hearing decline in some blue-collar occupations, mainly among men. Results for women could however be affected by few participants in the investigated occupations. In several occupations, the workers had similar hearing declines as clerks, which could point to effective protective measures. This study provides important information on long-term hearing decline in various occupations, which is valuable for further work towards preventing hearing loss in the workplace.
Keywords*:* hearing deterioration; hearing loss; occupational; work-related

412 - A longitudinal study of the prevalence of noise- induced hearing loss in childhood
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Importance Hearing loss can lead to a number of disabilities, subsequently reducing the quality of life. In recent years, there has been a rise in the number of people listening to loud sounds in recreational settings, which puts them at risk of irreversible hearing loss.
Objective To examine the change in prevalence of noise- induced hearing loss (NIHL) between ages 9 and 13 years.
Methods This study was embedded within Generation R, a population-based prospective cohort study from fetal life onwards in Rotterdam, the Netherlands. Hearing assessment was performed at the age of 9 and repeated at the age of 13 years. Pure-tone thresholds were obtained at 0.5 to 8 kHz, and tympanometry was performed in both ears. Children with missing or failed tympanometry results were excluded.
Outcome Measures Audiometric signs suggestive for NIHL included a notch and/or high-frequency hearing loss.
Results A total of 3675 participants, of whom 51.3% were women, were included in the analysis. The mean (SD) time interval between baseline and follow-up was 3 years and 10 months (5 months). The prevalence of NIHL increased from 9.8% (95% CI, 8.8 to 10.8%) to 11.7% (95% CI, 10.7 to 12.8 %) between aged 9 and 13 years (p=0.004) due to the increase in number of participants with a notch.
Conclusion
The number of participants with audiometric signs suggestive for NHL increased by 1.9%. This hearing impairment is already present at young age and may have lifelong consequences. Therefore, we believe it is important to raise awareness and educate adolescents about the harmful effects of excessive noise on hearing.

29 - The prevalence, behavioural and management outcomes of infants with Auditory Neuropathy Spectrum Disorder within a large cohort of newborns
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Objective: To provide an overview of electrophysiological and behavioural outcomes from a large UK centres data on children diagnosed with auditory neuropathy (ANSD) between 2002 and March 2019
Design: A systematic audit, collating the electrophysiological data from ABR follow up, riskfactors and later behavioural results / management. These were then compared to look for trends between groups.
Study Sample: 118,925 babies born, with 46 being diagnosed with ANSD (39 bilateral, 7 unilateral)
Results:

- 29% of ears with ANSD had short latency components on ABR testing
- 44% of ears with present cochlear microphonics but absent transient evoked otoacoustic emissions (TE-OAE) and no ABR went on to have profound behavioural hearing threshold levels
- All but one child (97.8%) went on to show a hearing loss on behavioural testing.
- ANSD was not confined to the neonatal intensive care unit (NICU) population with 3 bilateral and 5 unilateral cases (23%) in the well-baby population.

Conclusions:

- Incidence of ANSD is higher in this sample than that reported previously in literature.

Children who have present of cochlear microphonics with absent ABR and absent TE-OAE have significantly worse later behavioural outcomes than other patterns of electrophysiological results.

485 - Recreational noise exposure and hearing threshold: a population-based follow-up study

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We used data from two study waves (1998 and 2018) of a large population-based hearing study in Norway, the HUNT study. Both study waves included pure-tone audiometry and a questionnaire. Our study included 12,115 participants who participated in both study waves. There were 57 % women, and mean age at baseline was 43 years.
We used linear regression to assess the association between use of personal music players (PMPs) and hearing threshold. We examined three exposure variables: 1. PMP use overall (yes/no), 2. PMP duration (1-2/2-6/>6 hours per week), and 3. PMP sound volume (low/medium/high). Non-PMP use was used as reference. The outcome variable, hearing threshold, was defined as the pure-tone average over the frequencies 3, 4, and 6 kHz. We adjusted for baseline hearing threshold, age, sex, education, noise exposure, ear infections, head injury and daily smoking.
The PMP use increased from 8% in 1998 to 30% in 2018. Compared to non-users, neither PMP use (yes/no) nor PMP duration (hours per week) was related to hearing threshold. On the other hand, sound volume was related to hearing threshold: listening at low sound levels was associated with better hearing thresholds (-2.5 dB [-4.1 to -0.8]), while listening at high sound levels was associated with somewhat worse hearing thresholds (1.4 dB [0.1 to 2.8]).
Our large population study showed no association between normal PMP use and 20-year hearing progression in the general adult population. However, users listening to high sound levels increased their hearing threshold compared to non-users.

200 - Prevalence of Hearing Trouble, Diagnoses and Use of Services in Early Primary School: The U.S. Early Childhood Longitudinal Study–Kindergarten Class of 2010–11

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Introduction**:** The Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011) is a study of child development, early learning, and school progress that seeks to understand how early experiences relate to later development, learning, and academic achievement. Objective: To describe prevalence and risk factors for parental reports of hearing trouble (HT), professional diagnoses of HT, and use of services in early primary school. Methods: ECLS–K:2011 children were drawn from a randomly-selected national sample of public and private schools in 2010–11 and then followed longitudinally from kindergarten entry through 5th grade. The ECLS-K:2011 is a multisource, multimethod study that included administered standardized achievement tests in schools, interviews with parents/guardians, and questionnaires completed by teachers, school administrators, and kindergarten before- and after-school care providers. Information about children's health, including HT was reported by parents; additional information was provided by teachers, schools, and daycare providers. The sample of children enrolled longitudinally at each wave declined slightly: kindergarten (n~13,040), first grade (n~12,360), second grade (n~11,600), third grade (n~10,520), fourth grade (n~10,140), and fifth grade (n~9,390). Report of children's hearing (without use of a hearing aid or other assistive device) was based on two questions:

1. Which best describes your child's hearing: (a) excellent? (b) good? (c) a little trouble hearing? (d) moderate trouble hearing? (e) a lot of trouble hearing? or (f) deaf?
2. Gallaudet Functional Hearing Scale—If any HT reported, can child usually hear and understand from across a quiet room without seeing the face of the speaker (yes/no): (a) whispers? (b) talking in a normal voice? (c) shouting? (d) when spoken to loudly in the better ear? or (f) can't hear or understand loud speech in the better ear? The first four response categories are asked sequentially until a "no" response, or the final category, is reached.

The following questions were also asked: "Has child's hearing ever been evaluated by a professional?", "Did you obtain a diagnosis of a problem from a professional?", and "What was the diagnosis?" Additional questions included use of hearing aids, cochlear implants, speech-language, hearing or other services, and whether the child was in a special needs class.

Results**:** Prevalence of reported HT was: first grade, 2.9%; second grade, 3.2%; third grade, 3.0%; fourth grade, 2.9%; and fifth grade, 2.4%. The results summarized here are from first grade. The prevalence of parent's report of excellent, good, a little trouble, and moderate trouble or worse were 65.2%, 31.6%, 2.7%, and 0.6%, respectively. Among those reported with "moderate or worse HT", 25.7% could hear and understand whispers; 42.9% a normal voice; 28.6% shouting; while 2.9% could not hear when spoken to loudly in the better ear. The hearing of 50.9% of the children was evaluated by professionals (doctors and other licensed persons such as school nurses, audiologists, and speech-language pathologists) during the past year. Among all children evaluated by professionals, hearing-related diagnoses were obtained for 4.8%. Among children reported as having HT by parents, a hearing-related diagnosis was obtained for 41.2%. Diagnoses included fluid in the ear (39.7%), ear infection (22.0%), ear wax (14.3%), ear drum problem (6.3%), hearing loss-cause unknown (4.9%), genetic cause (3.5%), ear canal deformity (2.1%), central auditory processing disorder (2.1%), deaf (1.4%), illness (0.7%), ototoxic exposure to drugs/medicines (0.4%), ear or facial surgery (0.4%), nerve deafness (0.4%), and other-unspecified (7.0%). Among those diagnosed with ear infections, 30.2% were also reported with fluid in the ear(s), whereas among those with fluid in the ear(s), 16.7% were diagnosed with ear infections. Among the children with professional diagnoses, 5% had hearing aid(s), however, an additional 2.5% did not use hearing aids, although recommended by a professional in the past year; 1.7% had cochlear implant(s). Among children reported as having any hearing or communication problem, 13.8% (26.8% among those with professional diagnoses) received therapy services or participated in programs for special needs children with disabilities.

Conclusion: Fluid in the ear, ear infections, ear wax, and ear drum problems were the most common diagnoses, accounting for three-fourths of the children with HT. While use of devices (hearing aids and cochlear implants) and speech-language and hearing services were strongly associated with severity of reported HT in early primary grades, some children appear to have been underserved.

463 - The prevalence of long-term otitis media related hearing loss in children and its impact on developmental outcomes

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Background Otitis media (OM) is a common cause of temporary hearing loss (HL) in childhood. However, for some children it may result in long-term HL lasting more than 3 months. Epidemiological studies of HL in childhood generally focus on permanent hearing impairment and not that due to OM. Therefore, the prevalence of long-term OM related HL is unknown as well as the potential impact that it may have on children's development.

Aims This research aims to 1) systematically review existing literature on the impact of long-term OM related HL on cognition and academic ability; 2) determine the prevalence of long-term OM related HL in the Avon Longitudinal Study of Parents and Children (ALSPAC) and 3) study the impact on cognitive, educational and mental health outcomes.
Findings The systematic review revealed weak evidence of long-term OM related HL having a negative impact on IQ and academic ability. In the ALSPAC study the prevalence of long-term OM related HL was 2.69% over the ages 7-15 years. This group had poorer IQ scores at age 15 than children without HL (verbal IQ: -4.72; performance IQ: -1.48). No associations were found with academic achievement at 15-16 years or anxiety and depression at 10 and 15 years.
Conclusion These findings indicate that the prevalence of long-term OM related HL is approximately 20 times higher than permanent HL in childhood. Furthermore, this HL has been shown to negatively impact cognition. Additional research is required to investigate the impact of this HL further and to determine how children can be better supported by clinical and educational services.
Key words: otitis media with effusion, childhood hearing loss, prospective cohort study, cognition, psychosocial

170 - Relationship between Inflammatory Food Consumption and Age-related Hearing Loss and Age-Related Central Auditory Processing Disorder in a Prospective Observational Cohort: the Salus in Apulia Study

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Background**:** The etiology of age-related hearing impairment is really heterogeneous, multifactorial and still discussed in modern science. A major hypothesis of aging and subsequently hearing loss regards inflammation. In recent years there have been a series of evidences that have linked the age related hearing loss with numerous aging disorders as cerebrovascular diseases (CVDs) and physical frailty. The prevalence of both age-related hearing loss or age related central auditory processing disorder (CAPD) and CVD is increased in older adults and these conditions often coexist, suggesting that there may be some common underlying factors. It is well known how serum markers of systemic inflammation increase with age and have been associated with cardiovascular outcomes and all-cause mortality. Preventing systemic inflammation and microcirculation abnormalities could be therefore a public health strategy to lower the incidence of ARHL and CAPD. It is also well described that systemic inflammation could be decreased or increased by consumption of peculiar foods and by specific dietary patterns. Hence, nutritional factors could be part of the repair the first damage to the hearing before it can reach an irreversible state and thus could constitute a step towards prevention of hearing loss. The objective of the present study was to test the hypothesis that pro-inflammatory foods consumption was associated with age-related hearing loss (ARHL) and age-related central auditory processing disorder (CAPD) in a population-based cohort of older people from a Mediterranean area.
Methods**:** Participants of the present study were enrolled from the electoral rolls of Castellana Grotte, Bari, Southern Italy within the MICOL Study. The baseline data (MICOL3, M3) were recorded from 2003 to 2005 and the follow-up data from 2013 to 2015 (GreatAGE Study -MICOL4, M4). All those studies were conducted within the "Salus in Apulia Study" a public health survey funded by Italian Ministry of Health and Apulia Regional Government and conducted at IRCCS "S. De Bellis" Research Hospital. We selected 734 participants (425 males). The examination was performed by an audiologist certified by the Italian law following the international standard ISO 8253-1:2010. All participants underwent to tympanometry and stapedial reflexes (Clarinet Plus, Middle Ear Analyzer, Inventis, Italy) to exclude middle and external ear disorders that could induce a conductive hearing loss. Peripheral ARHL was defined with a pure tone average threshold greater than 40 dB hearing level in the better ear. Dietary habits were assessed by a Food Frequency Questionnaire. CAPD was defined with a Synthetic Sentence Identification with Ipsilateral Competing Message (SSI-ICM) or a Contralateral Competing Message (SSI-CCM). Study population was examined at baseline (MICOL3) and after 12 years (GreatAGE Study). The association between ARHL or CAPD and single foods/food groups and micro/macronutrients was examined with adjusted logistic regression models.
Results**:** There were statistically significant mean differences in terms of increased consumption of fruit juices (10.02±5.92 *vs* 5.64±2.03), sugary foods (15.23±4.34 *vs* 11.77±1.96), caloric drinks (16.21± 16.16 *vs* 9.21±5.57), beer (39.68±42.23 *vs* 27.27±23.92), and spirits (2.52±2.93 *vs* 1.51±1.38) in the ARHL group compared to the normal hearing group. To better explain the effect of foods on the cochlear damage we investigated the micro-nutrients components. Only a significant increase of vitamin A dietary intake was evident in the normal hearing group (1177.66±99.71) compared to the ARHL subjects (1177.66±99.71). Furthermore, in the CAPD group compared to the normal hearing subjects, there were statistically significant mean

differences in term of increased consumption of grains (215.22±35.15 vs 196.25±37.48), sugars (15.06±4.46 vs 11.71±1.93), spirits (1.77±2.32 vs 1.06±0.65) and in term of decreased consumption of fruits (535.74±80.33 vs 651.39±98.14).
Conclusions**:** Adherence to anti-inflammatory dietary patterns and avoiding inflammatory foods like sugars and alcohol can be part of a healthy lifestyle protocol for the prevention of ARHL. Eating vitamins rich foods, like fruit, and avoiding sugar-rich foods, spirits and grains can be protective against the onset of CAPD.
Keywords: age-related hearing loss, central auditory processing disorder, presbycusis, population studies, diet, food, sugar, alcohol, inflammation

GENETIC ISSUES

127 - Identification of new candidate genes for hearing disorders using exome analysis

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Introduction**:** Hearing impairment is the most common sensorineural disorder in humans. Approximately 1 - 3 out of thousand newborns suffer from severe hearing loss or deafness at birth or in the first few years of life. The same numbers of children are deaf before reaching adulthood. Based on the form of the physiological defect, hearing disorders are classified into conductive hearing loss, sensorineural hearing loss, or a combination of both. Hearing disorders can be caused by environmental factors or viral infections, strong sources of noise, ototoxic substances and genetic causes. Hearing disorders can occur pre- or post-lingual and show a progressive course over several years from mild hearing loss to deafness. About ~ 60% of all prelingual hearing disorders are genetic. Inherited hearing disorders are divided into syndromal (SHL) or non-syndromal (NSHL). Almost 70% of cases of inherited hearing disorders are non-syndromic and mainly due to sensorineural causes. About 80% of the cases follow an autosomal recessive (DFNB) and 18% an autosomal dominant (DFNA) inheritance, about 2% are x-chromosomal (DFNX) or mitochondrial (MT) linked. A total of 187 gene locations have been described to date, for which 143 genes have so far been identified, 44 genes at least still unknown. The hearing impairment DFNB1, located in the chromosome section 13q11-12, is caused by mutations in the gene *GJB2* (connexin-26) [MIM 121011], as well as by deletions in the gene *GJB6* (connexin-30) [MIM604418]. Half of all cases of non-syndromic recessive hearing disorders are due to changes in this locus. Like NSHL, SHL has many different genetic causes. SHL are e.g. associated with malformations of the ear, inner ear or petrous bone; often there is also a coupling with other organic diseases.
Objective**:** The aim is to identify and characterize previously unknown genes and their gene products, which are the cause of autosomal recessive hearing disorders, and/or in combination with differentiated inner ear malformations, and on the other hand with the analysis of already known genes that were only described in the mouse models.
Patients and Methods**:** So far, 1261 patients have been included in the study, all of whom are clinically clearly characterized. All patients were diagnosed with a serious hearing impairment in the first two years of life, additional organic diseases or syndromes were excluded. Almost all patients (1229/1261) were recruited between 05/2003 and 06/2019 via a cochlear implant in the ENT clinic in Freiburg or the associated Implant Center Freiburg. In these patients, the genes *GJB2* and *GJB6* at the DFNB1 locus were first analyzed. Functionally relevant mutations were identified in 563/1261 (44.6%) of the cases. Important for the project is the group of patient which no mutations in the locus DFNB1, in the genes GJB2 (Connexin 26) and *GJB6* (Connexin 30); so far 698/1261 (55.4%) patients. In 158 patients in this group, a wide variety of inner ear malformations were identified. Exome analyses were performed on selected patients. With the next generation sequencing method, all previously known genes and their exons are sequenced in parallel, the bioinformatics and data analysis was performed, using the Ingenuity Variant Analysis software (Qiagen). The verification of identified genetic alterations with the NGS method was carried out by bi-directional sequencing (Sanger) of the coding exons, as well as the intron transitions.
Results**:** So far, two new candidate genes have been identified, as well as changes in rare genes for hearing impairment. The genes *DPP7* (MIM 610537), located on Chromosome 9q34.3 (DFNB33), and the gene *MUC16* (MIM 606154), located on chromosome 19p (DFNB81) two heterozygous mutations were detected; in the gene *DPP7* two splice side mutations and in the gene MUC16 missense mutations c.40666G>A, p.D13556N and c.40655C>T, p.T13552I. Perhaps both genes are involved in the development of rare cases of hearing impairment; these genes have not yet been analyzed in detail. In the gene *MYO15A* (MIM 602666) two heterozygous pathogenic variations were detected. A deletion c.3141delC, p.Pro1047fsX1124 and a

splice-side mutation c.IVS3+1G>A. The protein encoded by *MYO15A*, is critical for the differentiation and elongation of the stereocilia.
Conclusions**:** The project demonstrates that exome analysis is a powerful method to identify rare mutations and changes as well as new candidate genes for non-syndromic hearing disorders.

118 - Epidemiology of the hereditary sensorineural hearing loss in Russia

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Objective: Sensorineural hearing loss is one of the most common sensory disorders in humans. The incidence of sensorineural hearing loss is estimated to be 1 in 500 newborns. In Russia more than half of these cases is associated with mutation in *GJB2* gene. When the combined universal audiological screening was carried out high prevalence of mutations in *GJB2* gene in the Russian patients was revealed. But in some regions the low level of mutations of gene (Chuvashia, Bashkiria, Dagestan and other Southern regions) was noted. In some regions the accumulation of the frequent mutations (Altai Republic, Sakha-Yakutia) was also detected. The investigation of other deafness genes in *GJB2*-negative patients became possible with the next generation sequencing approach.
Aim: To study prevalence of hereditary hearing loss among children with bilateral sensorineural hearing loss.
Materials and methods: Genetic testing was expanded to screen 30 deafness genes using targeted genomic enrichment with massively parallel DNA sequencing. For this study 119 unrelated Russian *GJB2*-negative hearing loss patients were analysed.
Results: The genetic cause for 45 (38%) patients was diagnosed indicating that the present screening could efficiently identify causative mutations in hearing loss patients. Cases of syndromic hearing loss were diagnosed for 23 children clinically and confirmed in29 (24%) children with detection of mutations in the corresponding genes (*PAX3* (9%), *SLC26A4* (7%), *MYO7A* (4%), *CHD7* (4%), *EYA1* (4%), *COLL11A2* (4%), *COLL11A1* (2%). For 22 children with non-syndromic hearing loss mutations in 8 genes were confirmed (*STRC* (9%), *USH2A* (5%), *TMC1* 2 (4%), *TRSS33 1* (2%), *TRIOBP 1* (2%), *POU3F4* (2%), *MYO6* (2%). In cases of auditory neuropathy spectrum disorders mutations in OTOF gene (9%) were found out. Children with Usher syndrome type II and mutations in *USH2A* gene had hearing loss without clinical data for a vision disorder. 33 patients (28%) were identified with multiple mutations of uncertain value in different genes.
Conclusion: In our study the pathogenic mutations in 15 genes were revealed in 38% of *GJB2*-negative hearing loss cases (45/119). In 28% of cases (28/119) multiple mutations in different genes of uncertain value were detected. Development of molecular genetics methods allows to confirm the hereditary reasons in *GJB2*-negative patients, to study prevalence of hereditary hearing loss and to expand indications to consultation of families.

77 - Exome sequencing in infants with congenital hearing impairment: a population based cohort study

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Background
Congenital hearing loss is the most common sensory impairment and can be isolated or part of a syndrome. Diagnosis through newborn hearing screening and management through early intervention, hearing aids and cochlear implantation is well established in the Australian setting. However, beyond the most common mutations (mainly connexin), genetic diagnosis has remained out of reach for most patients with congenital hearing loss and their clinicians.
Aims and methods
We aimed to determine the genetic etiology of a population-derived cohort of infants with moderate-profound bilateral hearing loss born in the 2016-2017 calendar years in the state of Victoria, Australia, for whom hearing loss was detected through newborn hearing screening. Participants were identified through the Victorian Infant Hearing Screening Program. Recruitment occurred through two statewide paediatric hearing loss clinics where whole exome sequencing (WES) was offered. Care pathways following WES were modelled into a cost-effectiveness analysis to determine the incremental cost effectiveness ratio of WES compared with standard of care.
Results
Of those approached, 68% (106/156) consented to participate. The rate of genetic diagnosis was 56% (59/106), compared to just 21% (22/106) for the previous standard of care (*GJB2/6* sequencing only). This had important clinical benefits for the 106 participants: 36% required no further screening for medical comorbidities related to hearing loss and 15% had tailored management. Adding WES to the care pathway cost $1000 more per child but increased the diagnostic yield significantly.
Conclusions
WES was transformative in achieving a much wider range of definitive diagnoses for the majority of infants with congenital hearing loss identified through newborn hearing screening. The high diagnostic yield, clinical implications and cost-effectiveness indicate that genomic sequencing should become standard of care.
Keywords: genomics, congenital deafness, , diagnostic yield, clinical utility, cost-effectiveness

145 - Serum activity of MMP9 and its functional polymorphism as potential biomarkers of neuroplasticity in prelingual deafness treatment with cochlear implantation

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Treatment of congenital deafness with neural prostheses allows for effective acquisition of language skills, however considerable interindividual differences among implantees exist. To date very little or nothing is known about determinants of linguistic proficiency development, other than age of implantation, in children without comorbidities. Genetic and molecular biomarkers of neuroplasticity in prelingualy deaf children treated with cochlear implantation could facilitate their clinical management, especially rehabilitation, giving higher chances for development of robust proficiency of spoken language.
We investigated whether carrying of certain variants of genes encoding matrix metaloproteinase *MMP9* and *BDNF* and plasma level of MMP-9 and BDNF at CI activation is a prognostic marker of auditory skills acquisition outcome. We performed a prospective analysis of plasma level of MMP-9 at CI implantation in the group of 61 children, diagnosed with bilateral profound sensory- neural non-syndromic hearing loss, aged below 2, treated with cochlear implantation. Auditory development was assessed with Little Ears Questionnaire (LEAQ) before cochlear implantation, at 8 and 18 months after CI activation. Also the analysis of functional variants of *MMP9* and *BDNF* was performed. We studied associations between (i) functional variants of *MMP9* and *BDNF* (and their respective protein levels) and (ii) the child's auditory development (LEAQ) measured at the follow-up intervals. We have found, that the plasma level of MMP-9 measured at implantation was significantly correlated with the LEAQ score at 18 months follow-up. In the subgroup of the same genetic etiology of deafness (DFNB1-related), rs3918242 of *MMP9* was significantly associated with LEAQ score at 18 months follow-up. Also, according to a multiple regression model, the ratio of plasma levels of pro-BDNF/BDNF measured at implantation was a significant predictor of overall LEAQ score at follow-up.
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AUDITORY TRAINING CHILDREN

204 - Using auditory training and structured input to facilitate language development in children with hearing loss

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Many children with significant hearing loss receive auditory training (and sometimes speechreading training) throughout their childhood. Typically, the goal of speech perception training is to teach children to perceive the words that they already have acquired or to reinforce vocabulary that they are currently learning. We recently have expanded the focus in our pediatric clEAR speech perception training curriculum to emphasize the acquisition of language structures, in particular, bound morphemes.
Bound morphemes are morphosyntactic units attached to larger structures, and include the third-person *–s*, past-tense marker *–ed*, and possessive *–s*. Children with hearing loss tend to acquire most bound morphemes late in their language development or even fail to acquire some or all of them. At least two factors hinder their acquisition. First, bound morphemes are acoustically short in duration, are low level in intensity, and very often, are of high frequency. The second factor is that the lexical information conveyed by bound morphemes is often redundant with the information provided by lexically salient words (free morphemes) in an utterance. For example, in the sentence, *She walked yesterday*, the *-ed* is redundant with the final word.
Traditionally, children with hearing loss have been trained to perceive bound morphemes using interactive repetition, with a focus on learning the new form. For example, a teacher might ask a child, "What did Tom do yesterday?" If the child responses, "Tom walk school", the teacher will model the correct form and ask the child to imitate it. Many instances of this back-and-forth interactive repetition will go on throughout the school day. Unfortunately, even if a child can imitate correctly, the form may not be produced during spontaneous conversation.
Learners of second language also have difficulty in acquiring bound morphemes, to some extent, for the same reasons as do children with hearing loss (in particular, the redundancy factor). A successful pedagogical technique that has been shown to be effective with second language learners is structured input. Structured input forces learners to rely on the bound morpheme per se to extract meaning. For example, instead of asking learners to distinguish between sentences such as *He gave it to the two boys* versus *He gave it to the boy*, they would be asked to distinguish between *He gave it to the boys* versus *He gave it to the boy*. In this example, learners must attend to the presence or absence of the plural –s for comprehension because the free morpheme, *two*, is not available to indicate plurality.
In the experiment that will be described in this presentation, we blended auditory training and/or speechreading training with structured input. Our rationale was to teach language structures using structured input, and present stimuli through the channel that children who are normally developing would ordinarily learn language (i.e., through spoken language). Forty-three children with prelingual hearing loss, between the ages of 6 and 12 yrs, received either auditory training, speechreading training, or a combination of both. They were tested with a test designed specifically for this experiment before and after receiving speech perception training. The test allowed us to gauge changes in children's ability to both perceive and produce four different bound morphemes. A secondary goal was to compare the effectiveness of three training modalities (i.e., auditory-only, audiovisual, a combination of the two). The speech perception training was comprised of six computerized games, one of which emphasized perception of bound morphemes. For example, this game presented a phrase such as, *The girl jumped*, and then presented two response illustrations, one showing a young girl in the process of being up in the air, as if in the process of jumping, and another one showing that she has just landed. In this example, the participants were forced to attend to the final –ed in order to respond correctly. The children played the game one time each, during each of 16 sessions. The results showed a significant improvement in the ability to produce (albeit not perceive) bound morphemes, suggesting that structured input is an effective approach with children who have hearing loss.

COMORBIDITIES & MEDICAL ISSUES (1)

192 - In-Utero Opioid Exposure, Neonatal Abstinence Syndrome, and Infant Hearing: A KIDS Inpatient Database Review of Newborn Screening and Infant Hearing Loss

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Objective**:** Neonatal abstinence syndrome (NAS) is a condition of the newborn in which withdrawal signs and symptoms are displayed following exposure to an offending medication and/or drug of abuse. The vast majority of cases are due to *in-utero* exposure from maternal use of opioids during pregnancy, and like all problems stemming from the opioid epidemic, the incidence of NAS has increased. This has placed strain on not only an increasing number of patients, families and caretakers, but has also been responsible for a large economic burden within the healthcare system, estimated at $1.5 billion in the US in 2012. Prior studies have shown NAS patients to be at risk for poor utilization of prophylactic and specialty care. Poor healthcare utilization and being loss to follow-up is a concern for any condition, but this is especially true with newborn hearing loss. There have been no reports of clinically significant teratogenic effects of opioids leading to hearing loss in a newborn, nor has the rate of hearing loss in the NAS population ever been specifically assessed. However, there have been reports in adults of opioid use causing sensorineural hearing loss. Infants with NAS are a significantly vulnerable population and deserve special attention as they may face barriers to hearing healthcare after birth. The primary aim of this study was to assess the documented rate of failed newborn hearing screenings (NBHS) and diagnoses of hearing loss in NAS patients during their birth hospitalizations. Furthermore, by using a large national inpatient admissions database, we aimed to assess the association of NBHS screening results and patient demographics and socioeconomic factors.
Methods**:** The study examines the association between NAS and NBHS screening results in 2016 using the Kids' Inpatient Database (KID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. The database includes relevant diagnostic and procedure codes, as well as demographic data, for a national sample of pediatric inpatient hospitalizations. The 2016 HCUP/KID national database was used to identify a weighted sample of infants with failed NBHS/HL during birth hospitalization. Independent variables included diagnoses of NAS/in-utero opioid exposure, HL risk factor presence and sociodemographic data. Univariate analyses and multivariate logistic regression were used to determine associations between NAS and abnormal hearing assessment.
Results**:** The weighted study sample included 1,113,150 infants, of which 0.67% (n=21,888) had a diagnosis of NAS. NAS infants had lower odds ratio (OR) of documented failed NBHS (OR=0.76, $p<0.05$) than controls but a higher rate of HL diagnosis (OR=2.17, $p<0.01$). Certain sociodemographic factors had higher OR of abnormal hearing results, including race ($p<0.001$) (Black, OR=1.48 and Native American, OR=1.83), and Medicaid coverage (OR=1.45, $p<0.001$). A lower OR of HL diagnosis was observed in females (OR=0.84, $p<0.001$) and infants with higher household income (OR=0.53, $p<0.01$).
Conclusion**:** NAS children have a lower rate of inpatient documented failed NBHS and a higher odds of HL diagnosis during the birth admission. The complex medical care of these infants could complicate NBHS and subsequent follow-up. Certain sociodemographic factors including some racial and ethnic minorities, lower income level, residence outside a metropolitan center, and Medicaid insurance are associated higher risk of hearing loss.
Keywords: Neonatal abstinence syndrome, hearing loss, newborn hearing screen

126 - Temporal resolution abilities of individuals with and without diabetes mellitus type II with normal pure tone thresholds

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Purpose**:** Diabetes is one of the most prominent health emergencies of the 21st century, affecting millions of people worldwide. An estimate of 415 million individuals had diabetes in 2015, with more than 10% of those individuals living in the Sub-Saharan Africa region. Diabetes is classified according to aetiology. Diabetes mellitus type II accounts for more than 90% of cases. Since the disease is initially asymptomatic, 30% to 85% of cases remaining undiagnosed. Due to this delay in diagnosis approximately 20% of the individuals will have developed secondary complications. Auditory complications are often associated with diabetes; however, the extent and nature of these auditory manifestations are still unknown.

The main aim of this study was to determine and compare the temporal resolution abilities of adults with diabetes mellitus type II with normal pure tone thresholds to the findings of healthy age and gender matched controls without diabetes mellitus type II.
Method**:** A descriptive between-group comparative research design was utilized in this study. Purposive convenience sampling was employed to recruit individuals with and without diabetes mellitus type II. Fifty-six age and gender-matched participants (28 diabetic, 28 non-diabetic) between the ages of 20 to 60 years participated in the study. Pure tone audiometry was used to determine hearing thresholds while temporal resolution abilities, specifically the gap detection threshold, were determined using the GIN test and the RGDT. Psychometric functions were also constructed to determine differences between the two participant groups in terms of gap detection threshold as a function of gap duration (GIN test).
Results**:**
A statistically significant difference of $p<0.001$ was obtained for the mean gap detection threshold between the two groups for the GIN test. No significant differences were obtained for the total percentage correct scores between the two groups. Results for the RGDT regarding the arithmetic mean gap detection thresholds indicated no statistically significant difference (p=0.101) between the diabetic group and the non-diabetic group at all test frequencies. Finally, psychometric functions constructed for the participant groups with and without diabetes type II revealed that the gap durations that best distinguish the two groups are 5, 6 and 7 ms
Conclusion**:** Evidence of the present study suggests a strong association between diabetes mellitus type II and temporal resolution abilities (gap detection threshold). As temporal resolution is closely linked to speech in noise, more studies are needed in this regard.
Key words: Diabetes mellitus type II, Temporal resolution, Gaps-in-noise (GIN) test, Random Gap Detection Test (RGDT), Speech perception in noise

365 - A clinical test for enhanced auditory sensitivity for body vibrations in Superior Semicircular Canal Dehiscence Syndrome

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Patients affected by superior canal dehiscence syndrome (SCDS) complain about a specific hypersensitivity for internal body sounds (HIBS). SCDS is due to the presence of a dehiscence at the dome of the superior semicircular canal bone which functions as an interface between the inner ear organs and the brain. Those patients refer to an enhanced and often excessive hearing of cardiac pulse, own voice, breathing, joint movements, borborygmi or sometimes eye movements. This disorder may be enhanced to a level compromising sleeping, hearing and social communication and often disturbing the cognitive work. HIBS can be treated by a resurfacing of the bone dehiscence by surgery. Today there is only one screening test (the weber test at malleolus - with uncertain diagnostic precision) and a questionnaire available as clinical tests of HIBS. Given that the HIBS is the major complaint of SCDS and that there this can be treated by surgery, an objective measure of HIBS is worth consideration and clinically requested.
Here we present a new clinical test, developed to obtain a measure of the HIBS. It is a new application of the common psychoacoustic audiometry test in which the sound stimulation is provided by bone vibration at a distant point from the ear, specifically at the malleolus. This testing was experimentally proven by our research group (Brantberg K, Verrecchia L, Westin M. Enhanced Auditory Sensitivity to Body Vibrations in Superior Canal Dehiscence Syndrome. Audiol Neurootol. 2016;21(6):365-371.), however hard to translate into a clinical environment due to technical shortcomings, mainly using an experimental bone vibrator (the Minishaker B&K 4810 Bone Vibrator). In this study we have replicated the results obtained by the previous study, but using the new B250 bone conduction transducer, developed at Chalmers University of Technology (Gothenburg, Sweden) in collaboration with Ortofon A/S (Denmark) and designed for a clinical use (Fredén Jansson KJ, Håkansson B, Reinfeldt S, Persson AC, Eeg-Olofsson M. Bone Conduction Stimulated VEMP Using the B250 Transducer. Med Devices (Auckl). 2021 Jul 8;14:225-237).
The study was conducted by comparing the psychoacoustic hearing thresholds given by a group of 20 SCDS patients complaining of HIBS, with the thresholds of a group of 20 age matched healthy subjects. The subjects were stimulated by the B250 at malleolus with a bone conduction vibration consisting of a pure tone at frequencies 125, 250, 500 and 750 Hz and with intensity between 85 and 135 dB RMS FL. Results showed that the SCDS patients heard the bone vibrations at malleolus significantly at a significantly lower intensity than the control group for all the four frequencies tested. In particular, the 250 Hz frequency had the best diagnostic accuracy to separate SCDS cases from healthy controls according to a receiver operating

characteristic analysis. Translating these results in clinical terms, using a B250 stimulation at the ankle with a 250 Hz tone delivered at 125 dB RMS FL, it is possible to screen patients who are suffering of SCDS and referring to HIBS with a sensitivity of 100% and specificity of 85%. And more important, with a method easily scalable at the ordinary non-experimental audiological facilities, configuring an accessible clinical screening test for SCDS.

120 - Wideband tympanometry in ears with superior canal dehiscence before and after surgical correction

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Objectives**:** Wideband tympanometry (WBT) has been shown to be sensitive to mechanical changes in the ear. This study investigated the effect of surgical correction of superior canal dehiscence (SCD) on WBT (i.e. absorbance and middle ear resonance frequency) compared to those on common surgical outcomes such as symptom resolution, vestibular evoked myogenic potentials (VEMP), and hearing thresholds.
Study sample and study design**:** Seven patients (eight ears with SCD) who underwent surgical correction of SCD underwent WBT in addition to pure-tone audiometry and VEMP assessment.
Results**:** Postoperatively, all ears showed normalised/decreased absorbance at low frequencies and slightly enhanced absorbance in the middle frequency range (7/8 ears). The middle ear resonance frequency, which was initially lower than normal in most patients, increased in 6/8 operated ears, and decreased in two ears with no/partial symptom relief. In comparison, complete symptom control was observed in 6/8 operated ears, VEMP amplitudes reduced or normalised in all ears, and hearing thresholds remained stable or improved in 6/8 ears and worsened in two ears.
Conclusions**:** Surgery seems to change the response to WBT in patients with SCD. The results of WBT may represent mechanical changes induced by SCD, and should be considered when evaluating surgical outcomes.
Keywords: SCD surgery; Wideband tympanometry; absorbance; middle ear resonance frequency; superior canal dehiscence.

182 - The relation between size of enlarged vestibular aqueduct on computed tomography and progression of hearing loss: a retrospective analysis

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Background*:* In 10-15% of children presenting with SNHL the vestibular aqueduct (VA) is enlarged, making it the most commonly found inner ear deformity on Computed Tomography (CT) in these cases. Typically, an enlarged vestibular aqueduct (EVA) can occur both unilaterally or bilaterally. Patterns of hearing loss related to cases with EVA are diverse; profound hearing loss with acute and early onset to fluctuating and progressive or relatively mild and stable at older ages.
Objectives: This research analysed the dimensions of the enlarged vestibular aqueduct (EVA) in relation to the type and level of the hearing loss to develop a better understanding of the prognosis of hearing loss based on imaging findings in these patients. This outcome will help counselling of patients initially presenting with this entity.
Study design**:** retrospective longitudinal cohort study
Study population: 45 patients with a radiological diagnosis of a one or two sided EVA, with consecutive hearing assessments were identified within the records of the department of Otorhinolaryngology and department of Radiology of the University Medical Centre Utrecht, The Netherlands.
Methods: Demographic characteristics and outcomes of consecutive hearing tests were retrieved retrospectively of included patients, calculating pure tone averages (PTA) over 0.5, 1, 2, 4 kHz of tonal audiometry. Computed tomography measurements of distances of the labyrinth, including vestibular aqueduct midpoint, opercular and orifice width were taken. Linear mixed effects models were constructed to predict hearing in patients diagnosed with an EVA, using time, vestibular aqueduct dimensions, age at first presentation and side of EVA as factors.
Results: 45 patients (80 ears) were identified (18 male, 27 female) with a mean (median) follow up of 8.7 (4.8) years and an average of 7.4 tonal audiograms available per person. Mean (median) age of onset of hearing

loss was 2.5±5.8 year (0 year)(range 0-37.7 years). Mean (median) PTA of the affected ear at first presentation was 66.1 (67.7) dB. The mean (range) size of the vestibular aqueduct at midpoint was 3.0 (5.5) mm. Linear mixed models showed a PTA increase of 2.2 dB per year (95% CI 1.8-3.0 dB). Each millimetre of increase in the distance at midpoint of the vestibular aqueduct resulted in an increase of 8.0dB (95% CI 5.2-10.9) PTA.
Conclusion*:* Vestibular aqueduct size influences hearing loss over time in patients with EVA. This conclusion can help patients and clinicians in better understanding and counselling of the progression of hearing loss over time.

181 - Hearing loss in children with mucopolysacchiridoses after hematopoietic cell transplantation; a longitudinal analysis

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Aim**:** Mucopolysaccharidoses (MPS) is a lysosomal storage disorders caused by a deficiency of one of the enzymes involving glycosaminoglycan (GAG) degradation, leading to multi-systemic disease and, if severe, premature death.[8] Hearing loss of conductive, sensorineural or mixed origin, is frequently seen in patients with mucopolysaccharidoses (MPS). The conductive component of hearing loss is the result of seromucous otitis or ossicular chain deformities or disruption; the sensorineural hearing loss (SNHL) has been attributed to the accumulation of GAGs in the cochlea, auditory nerve, and brain stem.[12] Nowadays, hematopoietic cell transplantation (HCT) is applied to treat MPS types,[13] whereby this therapy has dramatically increased life expectancy in the past decade.[14] Although increasing overall survival, hematopoietic cell transplantation (HCT) increasingly shows disease progression in certain tissues. This study describes the longitudinal effect of HCT on hearing loss levels during childhood in patients with MPS.
Methods**:** Single institutional retrospective longitudinal cohort study of MPS patients under care of the Wilhelmina Children's Hospital Utrecht, The Netherlands. MPS patients treated with HCT between 2003 and 2018 received yearly audiological evaluation, including pure tone audiometry (PTA) or auditory brainstem response (ABR). Additionally, magnetic resonance imaging (MRI) of the cerebellopontine angle were performed and analyzed.
Results**:** 38 patients (28 MPS-type 1, 2 MPS-type 2, 2 MPS-type 3, 2 MPS-type 4, 4 MPS-type 6) were analyzed (95% with normal enzyme activity levels and mean age at transplantation of 1.2 years; range 0.2-4.9 years). The median follow-up after HCT consisted of 5.0 years (range 0-16 years). Air conduction threshold decreased significantly over time ($p<0.05$) with a mean PTA at 1 year post-HCT of 50±0.7 dB to 23±11 dB at 13 years follow-up. Bone conduction threshold however increased over time with a mean PTA at 1 year post-HCT of 10±7 dB to 18±9 dB at 13 years follow-up. The degree of hearing loss varied from mild-severe early post-HCT to normal-mild at longer follow-up. The type of hearing loss shifted from conductive in the first years post-HCT to sensorineural hearing loss at longer follow-up. MRIs of the cerebellopontine angle did not show abnormalities.
Conclusion**:** Hearing loss is still seen in patients with MPS despite HCT and shifts from a conductive type early after HCT to a sensorineural type later in childhood and with longer follow-up. Considering this outcome, yearly follow-up with an otorhinolaryngologist and hearing assessment is necessary to timely intervene in this group of children with multiple comorbidities.

423 - The ears and hearing: the role in reproduction

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A connotation on the role of hearing in reproduction can be found in Christian religious believe of divine conception of the Virgin Mary by the "Word of God".
Hence, in the medieval Western Europe, the women's ears were considered the private parts and uncovered ears were socially unacceptable.
However, the contribution of hearing to reproduction is not only a fiction or religious believe. The scientific knowledge and technology have provided an insight that the ears and hearing may indeed play a role in reproduction of animals and humans.
The oestrogen receptors are present in the cochlea and at different levels of the central nervous system. Together with the steroid receptors, which are also present in the cochlea, they provide a physiological basis

for direct and indirect effects of oestrogen and progesterone on the auditory system through a complex neuro-endocrine network.
Our research data suggest that hearing sensitivity is modulated by the reproductive hormones, with the best hearing acuity around the time of ovulation. A direct correlation between the oestrogen levels and hearing sensitivity is consistent with an excitatory effect of oestrogen on the auditory system.
The research findings imply that the auditory function is modulated as a part of the auditory adaptation, to enhance the process of reproduction.
Key words: Hearing, oestrogen, reproduction

154 - Hearing Screening for congenital CytoMegaloVirus – a feasibility and acceptability study of targeted salivary CMV screening for the early diagnosis of CMV associated hearing loss

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Background**:** Congenital cytomegalovirus (cCMV) is the leading infectious cause of sensorineural hearing loss (SNHL), and accounts for approximately 10-20% of congenital SNHL. Recent evidence suggests treating cCMV within one month of an affected baby's birth may be beneficial to preventing progression or development of hearing loss. Diagnosing cCMV accurately requires detection of the virus in the first 21 days of life.
Aims and method**:** The Hearing Screening for congenital CytoMegaloVirus (HearS-cCMV) study aimed to determine the feasibility and acceptability of additional salivary CMV screening at the time of the second positive (refer result) on the Newborn Hearing Screening (NHS) test across four maternity hospitals in Melbourne, Victoria, Australia. The study also aimed to assess if a positive cCMV screen enables expedited audiological confirmation, further investigations and assessment by a Paediatric Infectious Diseases specialist, and the timely initiation of anti-viral treatment if appropriate. Parents received information about cCMV screening at the time of their baby's second positive 'refer' result on their NHS. Parents took a saliva swab from their infants, swabs were returned via mail. CMV nucleic acid detection using real-time polymerase chain reaction (PCR) was performed at a central hospital laboratory service. Primary objective was determined by the number of infants who completed the cCMV swab at ≤21 days of age as a proportion of those who returned a refer result on their second NHS at ≤ 21 days. Secondary objectives included analysis of parent acceptability through a short parent completed survey, cCMV prevalence, timeliness of diagnosis in relation to audiological diagnosis and Paediatric Infectious Disease specialist consultation and prevalence of hearing impairment in cCMV.
Results**:** 96/126 (76%) consented to the saliva testing with all swabs completed within 21 days and results received within 30 days. cCMV prevalence was 1.06% (1/96). Most parents indicated that testing was easy to do (63/65, 97%), a good idea (59/64, 98%) and they were glad their baby was screened (63/65, 97%).
Conclusions**:** Results support the feasibility and acceptability of targeted salivary CMV screening through the NHS allowing accurate diagnosis of cCMV related SNHL and appropriate audiological and infectious disease management.

COMORBIDITIES & MEDICAL ISSUES (2)

16 - (Intractable) Localization- related symptomatic epilepsy in patient with Bilateral Cochlear implant: A Case Report

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13 years old female child patient diagnosed with bilateral congenital sensory neural hearing loss when she was 2 months of age. Patient had strong family history of hearing loss as her grandmother and parent's uncles were deaf- mute. Patient had bilateral cochlear implant in two different sitting, right ear was implanted on 11thAugust 2008 while the left ear done on 3rd May 2010 as per family request to do the operation in two different years. Patient has been regularly visiting in cochlear implant clinic for re-programming according to cochlear implant programming schedule. Patient's mother noticed that her daughter had several episodes of going in a trans-like state, stopping what she does and staring directly ahead. The episodes can last for a few seconds up to around 1 minute. There are no other clinical signs or evidence of jerky movements or any focal deficit. These episodes happened after she wakes up from sleep or when she is tired but there is no certain pattern for them. She had 1 episode which sound like complex partial seizure and 1 of these episodes happened while she was next to the swimming pool. After these episodes, on 1 or 2 occasions, she appeared confused and seemed to be doing some automatism. Physical examination revealed as normal without any evidence of neurocutaneous stigmata, abnormal neurological signs, any weakness or paralysis or any other neurological concern. This case diagnosed as (Intractable) Localization- related symptomatic epilepsy which showed no role of cochlear implant to trigger epilepsy. Patient followed up with pediatric neurology for couple of years then she underwent CT scan because she was not responding to medication, brain lesion was noticed in her image, accordingly she underwent brain craniotomy. Histopathology result was low grade glioma of brain.

460 - Investigation of the Effect of Screen Time on Balance in Children Aged 14-18 During the Pandemic

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Introduction: During the COVID-19 pandemic, television is the most common screen-based activity and type of education among children. However, computer use, video games, and ownership of devices such as tablets and smartphones are increasingly emerging from a younger age. Screen time, especially television viewing, has been negatively associated with the development of physical and cognitive abilities, and positively with obesity, sleep problems, depression and anxiety. However, looking at long-term immobility and screen time also causes balance disorders and instability.
Purpose: To investigate the effects of looking at the screen for a long time during the pandemic process on balance in children aged 14-18. To identify problems such as imbalance and balance disorders that children may experience and to produce rehabilitative solutions for problems.
Method: 30 volunteer individuals aged 14-18 years who applied with the complaint of imbalance were included in the study. After obtaining the demographic information of the individuals, the complaints of imbalance were questioned with the visual analog scale (VAS) after Videonystagmography to exclude peripheral vestibular patients, and the balance was evaluated with the dizzness handicap inventory (DHI) questionnaire and Computerized Dynamic Posturography. The duration of looking at the screen was questioned, and they were divided into 3 groups: 4-6 hours (group 1), 6-8 hours (group 2) and over 8 hours (group 3). The effect of the time of looking at the screen on the imbalance complaint was examined.
Results: The mean age of the individuals was 17.2±2.14 years. A significant difference was found between group 1 and group 3 according to VAS. According to the DHI survey results, there was a significant difference between the groups, and the combined balance score of the BDP results was found to be significantly correlated in group and group 3. At the same time, a significant difference was found between group 1 and group 3 according to the balance analysis.
Conclusion: The negative effects of COVID-19 are also seen in children. We are of the opinion that children should be in front of the screen for a long time during the pandemic process and that education should be developed and its effects should be investigated.

Keywords: Balance, COVID-19, Children, Screen time

408 - Preclinical adenosine receptor-based pharmacological therapies for hearing loss

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The signalling pathways activated by adenosine receptors (A_1R and $A_{2A}R$) regulate cellular responses to cochlear injury. Adenosine plays a pivotal role in cochlear protection by reducing oxidative stress and glutamate excitotoxicity, suppressing inflammation, improving blood flow and oxygen supply, and promoting anti-apoptotic pathways. We have demonstrated the otoprotective properties of the A_1R agonist adenosine amine congener (ADAC) in rats up to 48 hours after acoustic overexposure. Systemic administration of ADAC resulted in significant recovery of auditory thresholds, improved hair cell survival, and reduced oxidative stress markers in a time- and dose-dependent manner. A_1R agonists also provide cochlear protection in other forms of sensorineural hearing loss (SNHL), such as induced by cytotoxic drugs (cisplatin and aminoglycosides). This supports our view that A_1R is an essential regulator of cochlear survival in stress and injury.
Adenosine A_{2A} receptor ($A_{2A}R$) is also involved in neuroprotection, predominantly as a negative regulator. Our previous study in mice with genetic deletion of the $A_{2A}R$ demonstrated excellent preservation of sensory hair cells, cochlear afferent synapses, and spiral ganglion neurons after noise exposure causing cochlear tissue injury in wild-type mice. This study informed our current targeted approach to cochlear protection based on pharmacological inhibition of the $A_{2A}R$. Here, we investigated the effect of $A_{2A}R$ inhibition on cochlear survival after excitotoxic injury and with the development of age-related cochlear degeneration. Initially, we used organotypic tissue cultures of the rat cochlea at postnatal day 6 (P6) to model excitotoxic injury induced by co-administration of *N*-methyl-d-aspartate (NMDA) and kainic acid. The injury was characterised by a reduction in the density of neural processes and loss of afferent synapses in the presence of intact sensory hair cells. The administration of istradefylline (a clinically approved $A_{2A}R$ antagonist) reduced deafferentation of inner hair cells and improved the survival of afferent synapses after excitotoxic injury. This study provided evidence that $A_{2A}R$ inhibition promotes cochlear recovery from excitotoxic injury. Istradefylline may thus have clinical implications for the treatment of cochlear neuropathy and the prevention of hidden hearing loss (HHL), which presents as difficulties in speech discrimination in noisy conditions.
In the follow-up study, we investigated the effect of istradefylline on the development of age-related hearing loss (ARHL) in middle age C57BL/6 mice prone to early-onset ARHL. ARHL is the most common sensory disorder among older people, and yet, the treatment options are limited to medical devices such as hearing aids and cochlear implants. C57BL/6J mice were given weekly istradefylline (1 mg/kg) injections from 6 to 12 months of age. Istradefylline administration attenuated auditory threshold shifts by approximately 20 dB at mid to high frequencies (16 – 32 kHz) and improved hair cell survival in a turn-dependent manner. This study presents the first evidence for the cochlear rescue potential of istradefylline and highlights the role of $A_{2A}R$ in the development of age-related cochlear degeneration. Translational studies should aim to expand on the clinical potential of this treatment in the therapeutic management of ARHL and related cochlear sensorineural pathologies.
Keywords: hearing loss, cochlear protection, adenosine receptors, presbyacusis, glutamate excitotoxicity

511 - OCT-a Retinal Vascular Density, Age-Related Central hearing loss as predictors for global cognitive function in an Italian Older Population

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Introduction Hearing, balance, olfaction, and taste represent a complex sensory neural construct biologically linked to aging. Hearing and vision are the most explored senses, providing robust population-based evidence. Several studies have described their role as predictors in age-related neurodegenerative processes, particularly those related to cognitive decline. In particular, their role in the early and preclinical stages of cognitive declines, such as mild cognitive impairment (MCI), is not clear. Furthermore, new retinal imaging, based on OCT with angiography, provides further evidence of its role as an in vivo model of retinal neurodegeneration.
Objective This study aims to assess the role of peripheral and central hearing loss and retinal abnormalities as predictors for global cognitive impairment in the older population of Great Age \ Salus in Apulia Study.
- Methods: We analyzed data on 1829 older participants (65+) in the cross-sectional population-based Salus in Apulia Study. Optical coherence tomography angiography was used to measure SVD and DVD of the

capillary plexus of the macula at the 3-mm circle area centered on the fovea (whole retina), the parafoveal quadrant, and foveal quadrant. Disabling peripheral ARHL was defined as >40 dB hearing level of pure tone average on the frequencies from 0.5, 1, 2, and 4 kHz in the better ear, and age-related CAPD as <50% at the Synthetic Sentence Identification with Ipsilateral Competitive Message test in at least one ear. Global Cognitive functions were measured with Mini-mental State Examination (MMSE).
Results The median age of the sample was of 75 years (age range of 65–92 years), median education of 5, and 45% of males. For every unitary increase of DVD, there was a 0.07 increase in MMSE on average (95% C.I.: 0.02 to 0.12). When adjusted for both PTA and SSI-ICM in the same model we have noticed an effect modification and we tried an interaction using the new variable PTA multiplied for SSI-ICM. PTA and DVD used in the same model showed an increased effect of association and prediction power (Beta 0.48 95% 95% C.I.:0.31 to 0.51; c-statistic: 0.78).
Conclusions We identified a consistent association between age-related CAPD and deep retinal vessel density. ARHL, both at the peripheral and central level, and retinal vessel changes have both been associated with neurodegeneration/dementia, exploration of the retina by OCT-A imaging, as an in-vivo model, may help to better understand the complex neurobiological relationship between auditory changes and dementia. Early deep retinal vessel changes in older subjects without hearing disorders may be predictive of the subsequent development of age-related CAPD. Age and peripheral hearing loss and deep retinal vascular features are interlinked in some way. This finding should be investigated in relation to other senses (taste and olfaction).

COMORBIDITIES & COMPLEX NEEDS

187 - Intervenor Services across Lifespan of individuals with deafblindness in Ontario, Canada

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Introduction**:** The World Federation of Deafblind report “At Risk of Exclusion from CRPD and SDG’s implementation: Inequality and Persons with Deafblindness provided a global picture of the realities people with deafblindness face. It also estimated that between 0.2% and 2% of the world's population is deafblind.
This report highlighted a strong need to identify the needs of Canadians with deafblindness or dual sensory loss to ensure timely screening, assessment, and deafblind-specific services aimed to maximize autonomy and improve quality of life across the lifespan of individuals.
The prevalence estimates obtained from the Canadian Survey on Disability 2017 suggest that around 1.66% of the Canadian population above 15 years of age has deafblindness, while approximately 1.95% of Ontarians above 15 years of age have deafblindness. The estimates suggest that the prevalence of deafblindness increases with increasing age, both in Canada and Ontario, indicating the strong relationship between ageing and concurrent hearing and vision loss. These findings align with those of the World Federation of the Deafblind’s report (2018) and support findings provided by DeafBlind Ontario Services in their previous position papers (2018 and 2019)
DeafBlind Ontario Services provides accessible residential and customized support services across the province of Ontario in Canada. Our holistic approach to Intervenor Services empowers people with deafblindness to achieve their goals and dreams.
Our team of professionals are dedicated to ensuring consistent and holistic person-centered plans are in place for each person we support to live full, meaningful lives. Our highly regarded service model is multi-faceted, encouraging each individual to achieve their own goals and aspirations. Our approach is just one of the ways we are unique in the sector and part of what sets DeafBlind Ontario Services apart in our field.
Objectives**:** The overall goal of the Intervenor Services Human Resource Strategy (ISHRS) was to professionalize Intervenor Services, increase the availability of highly skilled staff, and improve the quality of Intervenor Services delivery to adults living with deafblindness in Ontario. The oral presentation will focus on behavioural and technical competencies for an Intervenor who act as an ‘eye’ and ‘ear’ for the individual with deafblindness.
Methods: Intervenor Services Strategy Between 2015 and 2018 under the co-leadership of DeafBlind Ontario Services, the ISHRS was a partnership between the Ministry of Community and Social Services (MCSS) and the agencies that provide Intervenor Services, towards the transformation of Intervenor Services in Ontario.
The key objectives of the ISHRS:

- increased recruitment of intervenors;

- improved onboarding process for intervenors;
- improved access to professional development and training opportunities;
- improved access to appropriate educational programs and certificates for people interested in training as intervenors;
- enhanced retention of highly qualified intervenors; and,
- stronger partnerships among key organizations including associations, colleges, agencies and ministries

Results The ISHRS key deliverables were: development and implementation of behavioural and technical competencies for Intervenor Services; development of a best practices in human resources toolkit for Intervenor Services;; and, development and implementation of a marketing and communications strategy for the Intervenor Services sector.
Conclusion A certification process to formalize the professionalization of the field of Intervenor Services is complete. It will be open to any intervenor across Ontario, Canada and potentially internationally if they so choose. A global dialogue is needed to inform these evidence-based practices in research and rehabilitation as well as interdisciplinary collaboration between researchers and service providers specializing in vision and hearing fields.
Keywords: Deafblindness, Intervenor Services, Prevalence, Vision and hearing disability

176 - Hearing screenings, diagnostics, and treatement of hearing loss for people with intellectual disabilities in their life environment in Germany

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The prevalence of hearing loss in people with intellectual disabilities (ID) is significantly higher than in the general population and is around 25% in younger and middle-aged adulthood. These people rarely seek help on their own. The majority of their hearing losses are not or inadequately treated. National and international guidelines have been developed calling for regular hearing screenings for people with ID, but such screenings have not yet been implemented to a greater extent. In a German project involving 120 people with ID, several audiometric methods were tested in a sheltered workshop to determine their suitability and reliability for use in the living environment of people with ID. Two tone audiometric and two speech audiometric methods proved to be most valid. Suitable objective methods were impedance audiometry, TEOAE and - with some limitations - DPOAE growth functions. In a project funded by the German government*, hearing screenings are now being conducted on 1050 people with ID in their family homes or homes for the disabled, sheltered workshops or workplaces, special schools, and kindergartens. If screenings are failed, an immediate diagnosis follows. If possible, therapy is carried out directly on site, for example removal of cerumen, medication, or fitting with hearing aids. If no on-site treatment is possible, people will be referred to an ENT clinic. After one year a re-evaluation takes place. If this procedure proves successful, it will be introduced in Germany as a new form of medical care and financed by the health insurance funds.
We assume that the implementation of a program of systematic hearing screening, diagnosis, therapy initiation, and long-term monitoring in the living environment of people with ID is feasible and results in a better reduction of untreated or inadequately treated hearing loss in this underprivileged population than so far.
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128 - Temporal resolution and speech perception in noise of adults with and without HIV with normal audiometric results

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Purpose:
The Human Immunodeficiency Virus (HIV) epidemic is now in its third decade and it is growing to be one of the greatest health challenges the world has to face. At the end of 2018, the UNAIDS estimated that there were about 37.9 million people globally infected with HIV. It was also estimated in 2018 that 7.7 million

members of the South African population were living with HIV. A disorder of the auditory system, such as a hearing loss, is one of the many effects that the HIV virus may have on the human body. Furthermore, central nervous system (CNS) damage can be a devastating consequence of HIV infection. The majority of research that was done regarding hearing in individuals with HIV has focused on peripheral hearing loss, with limited research reporting on auditory processing.
The main aim of this study was to determine the temporal resolution abilities and speech-in-noise perception of adults with HIV with normal audiometric results (audiograms) and to compare the findings to those obtained from healthy age and gender matched controls without HIV.
Method: A descriptive, cross-sectional comparative research design was utilized in this research study. Purposive convenience sampling was used to recruit participants with and without HIV**.** This research study consisted of a HIV group (n=20) and an age and gender matched HIV negative control group (n=20). All the participants in this study were in the age range of 18 to 40 years, had already been diagnosed as HIV negative or positive, and had audiometric and acoustic immittance test results that could be classified as normal. The auditory tests used for participant selection included immittance testing and pure tone audiometry. The procedures used for data gathering consisted of auditory processing tests including the Digits-In-Noise Test (DIN), the Gaps-In-Noise Test (GIN), and the Random Gap Detection Test (RGDT). The two groups of participants were compared based on the results of the auditory processing tests.
Results**:** The results for the RGDT regarding the mean gap detection threshold indicated a statistically significant difference ($p<0.001$) between the HIV and control group at all test frequencies. A statistically significant difference of $p<0.001$ was obtained for the total percentage correct scores as well as the mean gap detection threshold between the two groups for the GIN test. Finally, a statistically significant difference was found between the two groups when speech-in-noise abilities were measured through the DIN test.
Conclusion**:** This study provided more information on the effects of HIV on speech perception in noise, auditory information processing and more explicitly on temporal resolution. Evidence of the present study suggests a strong association between HIV and temporal resolution abilities. If individuals with HIV present with temporal resolution deficits it could lead to speech-in-noise difficulties, as this processing ability is a precondition for comprehending speech in background noise as well as in quiet, as speech sounds fluctuate over time.
Keywords:
Auditory processing, Digits-In-Noise (DIN) test, gap detection threshold, Gaps-In- Noise (GIN) test, Human Immunodeficiency Virus, Random Gap Detection Test (RGDT), speech perception in noise, temporal resolution.

Round Table
AUDITORY PROCESSING DISORDERS
Organized by the European APD Group and EFAS APD Working Group

475 - Clinical presentation of APD in different paediatric and adult populations Central Auditory Processing Disorders
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CAP or APD, is a recognised diagnosis in ICD-10 (under H93.25), however there are still diagnostic controversies. Cognitive and language aspects to be taken into account when considering this presentation.
In addition to developmental causes of APD, and sound deprivation related APD there are several different neurological conditions that might directly or indirectly impact on auditory processing (AP) depending on the nature, extension, and site of the brain damage. These include stroke, brain trauma, epilepsy, demyelination, and degenerative syndromes that may lead to APD. Evaluation of auditory processing in all cases of children and adults with reported listening deficits in the presence of normal audiograms is important in order to implement deficit driven management strategies that are needed to support the patient's communication and overall wellbeing. This presentation will discuss the presentation and the diagnostic approach in children and in adults with autism and neurological disorders in order to demonstrate how different aspects of cognition and of auditory processing need to be considered to make the diagnosis of APD and the extra value of APD assessment for appropriate management of these patients.

17 - Cognitive and linguistic interaction in auditory processing

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Auditory deficit, particularly in children, are likely to affect cognitive factors (such as attention and auditory memory). Hence, tests for cognitive abilities may be negatively affected by auditory deficits. Recent data has highlighted that poor evaluated cognition may be the result of not taking into account an auditory deficit (Iliadou et al, 2018). There is also the counter argument that cognitive skills influence auditory processing (e.g., BSA, 2011) and tests used to identify auditory processing disorder (APD) may be influenced by cognitive factors, such as auditory attention (Sharma et al., 2009). Clearly, there exists a relationship between auditory attention/memory and auditory processing skills. Yet APD testing does not necessarily include cognitive diagnostic tasks (Stavrinos et al, 2018). It is crucial to include tests for attention when devising an assessment battery for APD.

Meanwhile, the need of 'verbal' based auditory processing tests, as part of the assessment battery for APD, cannot be overstated. Such tests include non-word repetition tasks (NWRT), both in quiet and in noise. Individuals with APD often complain of difficulties with understanding speech in noise and the traditional pure-tone sensitivity test will not detect such difficulties. NWRT is used clinically as a measure of phonological memory. NWRT in noise has been found to distinguish between typically developing children and those with APD (e.g. Tabone, 2018). Besides, bilingual speakers are reported to perform differently on speech-in-noise tests compared to monolingual speakers (e.g. Krizman, Bradlow, Lam & Kraus, 2016).

Another useful linguistically based test which assists with differential diagnosis of APD is the sentence recall /imitation task (SIT). This test has been found to be a strong predictor of verbal comprehension (e.g. Grech, Franklin & Dodd, 2011). Children with APD are not expected to have difficulties with SIT and administering the latter will contribute to differential diagnosis.. However, both NWRT and SIT are often unavailable in languages other than English. Simple translation of English tests is not a scientific valid way of developing such tests and it is clearly contraindicated to adopt such procedures. Hence, there is the need to develop and standardise such tests based on specific language/s and cultural characteristics (such as bilingual contexts). The European APD Group is making a joint effort to encourage researchers and clinicians to develop such 'speech based' tests to have a clearer understanding and more accurate differential diagnosis of APD.

8 - Auditory processing disorder- clinical battery as a gold standard approach

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Individuals with auditory processing disorder (APD) typically report listening difficulties in challenging auditory environments, despite a normal audiogram. There are no core symptoms unequivocally and specifically indicative for APD. Frequently reported symptoms which cannot be explained otherwise could warrant an APD diagnostic assessment: difficulties understanding speech in noisy environments, problems locating the source of a signal, failure to respond correctly to verbal information, frequently asking for repetition of information, reduced attention to auditory information, distractibility and problems with oral and written language.

Traditionally, APD is defined as a specific deficit in the perceptual processing of auditory information in the central auditory nervous system (CANS), including the bottom-up and top-down neural connectivity. Impaired auditory processing beyond the auditory nerve impact on the auditory perception of speech and other complex auditory stimuli, not assessed by classical audiological evaluation. As APD covers several aspects of audition, one test alone cannot address all dimensions of APD. Thus, audiometric tests in conjunction with tests for auditory processing provides an ecological approach to auditory perception and hearing in everyday life. According to the European APD consensus (2017), the gold standard battery approach is the currently used diagnostic tests for auditory processing evaluation. Test batteries comprising of several behavioural psychoacoustic tests of verbal and non-verbal stimuli form the basis of an evidence based approach to differentiate APD from other disorders, taking into account both clinical expertise and research. The APD test battery may be supplemented by electrophysiological or objective audiological measures, such as acoustic reflex thresholds, tympanometry, auditory brain stem responses or otoacoustic emissions.

APD diagnosis requires evaluation of multidisciplinary information of the client's profile being essential to test selection and interpretation of test results. The diagnostic process is facilitated by evaluating the individual behaviour as measured by specific questionnaires and detailed clinical interview, including audiological history. When choosing the auditory processing tests, language and cognitive confounds should be minimized. In some cases, a detailed receptive and expressive language evaluation may be necessary to choose appropriate tests and identify language development impairments at higher level, which may impact audiological results. Cognitive resources, like working memory and attention, may influence on understanding acoustically degraded speech and test results. However, as stated by the European APD consensus group (2017), cognition is **not** considered the primary aetiology for APD.
To assure that the audiological findings are not primarily the result of a higher-level disorder, the need for a multi-disciplinary approach to diagnosis of APD is advocated. Medical history concerning symptoms, previous bouts of otitis media, specific difficulties, onset of disorder and musical training are taken into account to conclude whether an individual has APD or a comorbid challenge, or if APD coexist with other disorders or multimodal deficits.

76 - Auditory Rhythm Related Deficits in Primary School Children with Auditory Processing Disorder
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Auditory processing disorder (APD) is defined as a specific deficit in the processing of auditory information along the central auditory nervous system, including bottom-up and top-down neural connectivity (Iliadou et al., 2017a) and is currently classified in the international statistical classification of diseases and related health problems, 10th edition (ICD-10) as H93.25. Its most encountered symptom is impaired speech in noise recognition.
Even though music comprises a big part of audition and some evidence point to deficits in music perception in APD children, assessing music and particularly rhythm perception in this population has not yet gained wide attention in research. Here we present a series of experiments testing the hypothesis that rhythm perception and rhythm priming effects are impaired in APD children. Rhythm perception here refers to the perception of the simplest kind of rhythm possible, that is, short isochronous beat sequences. Rhythm priming effects refer to the well documented effects of enhancements in processing of a variety of auditory stimuli, here specifically of speech in noise, that follows a rhythmic auditory stimuli. Correlations with verbal and non-verbal auditory processing and cognition were assessed in both experiments.
In a pilot experiment we tested whether rhythm priming effect are present for speech in noise recognition in neurotypical children as measured via a Word Recognition - Rhythm Component (WRRC) test. In this test a 4 beat sequence is presented followed by a target word in noise, which is to be recognised. Depending on the arrangement of the beats and the word, each presentation takes the form of one of three conditions: in Rhythm and Unsynchronised conditions the sequence is isochronous and the word is either sychronised or non-synchronised respectively to the sequence, in terms of musical rhythm. In non-rhythm condition, the sequence is non-isochronous. Twenty-seven typically developed 10-year-old children were tested for this experiment. Results suggested an enhancement in recognition when the word was synchronised, that is, recognition was better compared to when the sequence was non-isochronous, and a smaller effect when the word was non-synchronised with the sequence.
In the second experiment, 40 APD children and 33 neurotypical ones were tested through the WRRC test confirming a deficit in rhythm priming effects on speech in noise recognition. Results suggested also that the deficit is linked to non-verbal auditory processing, and it is only weakly dependent on cognition. In the last experiment 39 APD and 25 neurotypical children were tested through a rhythm perception test, i.e. Isochrony task, where the task was to identify a small deviation in an otherwise isochronous sequence. Results suggested a deficit in rhythm perception, not related to cognition but correlated to the perception of classic (i.e. no priming) speech in noise.
All results are discussed under the theory describing the neural mechanics of rhythm perception, i.e. neural entrainment. This theory describes how neural oscillations that are forced to be synchronised by and with a periodic stimuli influence the perception of the periodic stimuli itself, and the perception of any forthcoming one. We suggest that part of this mechanism is impaired in APD. As neural entrainment is a part of the speech recognition mechanism, this interpretation also explainsa part of the deficits in speech in noise recognition seen in APD children. We further suggest the potential benefit of the use of music/rhythm training as a

remediation technique for APD, as well as the future possible use of Isochrony and WRRC tests in clinical practice.

LISTENING EFFORT (1)

414 - A Systematic Review of the Correlations Between Measures of Listening Effort and Their Association with Fatigue

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Background: Listening effort (LE) describes the cognitive resources needed to process an auditory message. Our understanding of this abstract notion remains in its infancy which hinders our ability to effectively delineate how it burdens individuals with hearing impairment. This is further complicated by the fact that, despite the myriad of proposed measurement tools for LE, a validated method for capturing LE remains frustratingly elusive. Current measures can broadly be split into three categories: *Effort based questionnaires:* self-reported measures tapping into perceived effort expended on a task, examples include the NASA task load index or LE visual analogue scales; *Behavioural measures:* use performance indices to ascertain an individual's effort levels, examples include response times in a dual task paradigm; *Physiological measures:* infer effort from a range of biomarkers, examples include cortisol, pupil data and EEG oscillations. Additionally, many papers tried to capture a negative consequence of LE through fatigue-based questionnaires such as fatigue visual analogue scales. An emerging model explaining the lack of consensus for a validated outcome measure is gaining traction within the audiological community and describes the possibility of the multi-dimensional nature of LE. It surmises that each theme may capture a different component of the cognitive pathways which underpin the concept of LE. Individual studies have reinforced this idea by demonstrating that correlational analyses between measures of LE often produce weak and insignificant results, however currently no systematic review of this topic has been undertaken.
Objectives: To perform a systematic review of the correlations between measures of LE and their association to fatigue questionnaires.
Methods: Five databases were used for this review – PubMed, Cochrane, EMBASE, PsychINFO and CINAHL. Search themes included derivatives of LE/Auditory fatigue AND Hearing loss. In total, 7,466 records were screened for title and abstract and full text. Inclusion criteria were determined using the Population, Intervention, Control, Outcome and Study design framework. This review compared each category of LE measure against itself, the other two categories and fatigue questionnaires to provide an insight into the inter-theme correlational results across all included studies. The quality of the evidence was assessed using the GRADE criteria and risk of bias with the ROBINS-I/GRADE tools depending on study design. Each correlational analysis was classified as demonstrating 'none', 'poor', 'fair', 'moderate' or 'very strong' association.
Results: Forty-seven papers met the inclusion criteria and were involved in the final analysis, equating to a total of 274 distinct correlational analyses. The total sample size of the included papers reached 1,885, stratified across hearing ability and age groups. Only 99/274 (36.1%) of trials reached significance. The most prevalent classifications within each comparison of themes were poor or fair. Moreover, when moderate or very strong correlations were observed there was a tendency for them to be condition specific, in that as the experimental conditions changed so did the strength of association. Together these results show that measures of LE are poorly correlated. Effort based questionnaires showed the most promise in terms of association, with fatigue questionnaires, suggesting that they may have a role in ascertaining this downstream consequence of LE. The overall quality of evidence from the included papers was judged to be very low with a serious risk of bias.
Discussion: The findings of this review add weight to the multi-dimensional concept of LE. This finding further diminishes the hope of a cardinal measure of LE. Instead, it may be more prudent to focus on capturing the consequences of LE rather than the notion itself. Established downstream effects of prolonged LE include fatigue, stress, low self-assurance and an increased desire to give up. Utilising pre-existing validated tools to measure these negative sequelae may represent the greatest potential to incorporate LE into clinical decision making. As shown by this review, effort questionnaires align with fatigue more closely than the other measures of LE and evidence the possible role they may have within this alternative approach. Limitations of this review include the quality of evidence from the included studies, low sample size of individual studies and high heterogeneity.

Conclusion: Measures of LE are generally poorly correlated with each other. Future work should focus on shifting approaches to capturing the negative effects of the LE rather than the concept itself.
Key words: Listening effort, Fatigue, Outcome measures, Correlations, Systematic review

35 - The auditory-cognitive perspective of speech understanding and listening effort
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Background Based on the Ease of Language Understanding model, speech understanding needs to be considered from an auditory-cognitive perspective. However, the auditory-cognitive perspective of speech understanding is not yet fully understood. Nevertheless, better insights in this perspective would be beneficial for, among other things, auditory rehabilitation in hearing-impaired elderly. Therefore, the current study aimed to determine the effect of external environmental and internal listeners' characteristics on speech understanding and listening effort.
Methods Twenty young- (age range: 18 – 29 years) and 19 older-adults (age range: 50 – 69 years) with age-appropriate hearing were subjected to an extensive auditory-cognitive protocol. First, audiological tests to measure hearing sensitivity and speech understanding in quiet and in noise were administered. Second, working memory, processing speed, selective attention, and cognitive flexibility and inhibition were evaluated. Third, listening effort in diverse listening conditions (i.e. quiet, (non)favorable noise condition, and 80% equated condition) was measured by means of a dual-task paradigm. In addition to these behavioral measures, a hearing-related quality of life questionnaire was used to examine participants' speech understanding and listening effort in daily life (i.e. subjective measure). To determine the effect of, among other things, age, sex, and cognitive performances (i.e. internal listeners' characteristics) on behavioral speech understanding and listening effort, simple and multiple regression analyses were conducted. A one-way repeated measure ANOVA was conducted to evaluate the effect of listening condition (i.e. external environmental characteristic) on behavioral listening effort. Spearman correlations were computed to evaluate the association between behavioral and subjective measures of speech understanding and listening effort.
Results Results regarding the behavioral measures showed that for speech understanding in quiet, hearing sensitivity was the only significant predictor, whereas age group and processing speed were significant predictors for speech understanding in noise. The amount of listening effort increased with more taxing listening conditions. None of the auditory-cognitive variables showed a statistically significant association with listening effort obtained in the non-favorable noise condition. At all other listening conditions, age group was revealed as significant predictor for listening effort. In addition to age group, listeners' speech performances in noise were also associated with listening effort, howbeit only in the favorable noise condition. Last, the subjective outcome scores of speech understanding and listening effort showed similar trends compared to their behavioral counterparts, though the associations between subjective and behavioral measures were not always straightforward.
Discussion As speech understanding and listening effort deficits play an essential role in listener's quality of life, the auditory-cognitive interaction should be further unraveled. Consequently, evidence-based guidelines on how and which auditory-cognitive aspects should be evaluated in audiological practice can be formulated.
Key words: auditory-cognitive testing, speech understanding, cognition, listening effort

462 - Don't miss a thing! An integrative body response while listening to a complex acoustic scene with hearing aids
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Introduction**:** Real life comprises many different scenarios in which the sounds of interest can come from different directions, often simultaneously. Human hearing system developed to thrive in such scenes whereas the old age hearing loss was not part of that design. The first hearing aids tried to compensate for the hearing loss by offering no more than static, omni directional amplification of all sounds. Since then, the HA technology improved dramatically in order to accommodate real life, complex scenarios. And yet, the main HA benefit measure is still the old, "reliable", sit and repeat speech intelligibility test conducted in the "signal from the front,

noise from the back", static scene. In this study, we look at an integrative body response to a dynamic, demanding acoustic scene with three different hearing aid modes (omni directional presentation vs. two different modes of directional sound processing).
Methods**:** We simulated real life scenario using a free field system with 5 loudspeakers positioned in a circle arrangement at a distance of 1,15m from the center where the participants were located. Sensors (electrocardiography, galvanic skin response) for collecting responses of the autonomic nervous system to effortful listening situation were attached. An eye tracker collected eye movements as well as pupil dilation. Next, electrode placement on different auricular muscles (postauricular, superior, anterior, transverse) was accomplished in order to assess their vestigial (electromyographic) activity associated with spatial auditory attention. A wireless 64-electrode electroencephalography system was used to assess correlates of listening effort and listening fatigue within the central nervous system. After participant preparation and placement of the sensors, participants positioned their heads on a chin rest, and where instructed to look at a fixation cross in front of them while stimuli (sound streams) were presented. The participants had to follow podcasts presented at 0° and ignore distracting podcasts from +150° or -150°. From time to time, short informative sentences ("Hey-sentences!"; for example: Hey, next time I come from north east!), where presented randomly from +45°, -45°, +150° or -150° within an interval from 30 to 50 seconds. An additional main task for the participants was to attend to such sentences every time they heard one, and first move a joystick (placed on their right hand) to the direction they hear the sentence is coming and additionally listen to the content which would give them a hint of the position from where the next "Hey-sentence" might come. Also, they should score if the position hint from the previous "Hey sentence" was correct/false, by pressing particular buttons on the joystick. After each trial, participants answered some podcast-content related questions and gave their subjective impressions of, among others, listening effort, speech intelligibility, success solving the task. The experiment consisted on 10 trials of 12 minutes each. The first one was for training purposes on which participants had to solve the tasks without hearing aids. Next, for the following 9 trials, hearing aids with a particular hearing aid program should be used. Each program was used on 3 trials. In this pilot study, we analyzed a group of 10 young normal hearing participants (6m/4f, 25.3 +- 3.3 years) wearing hearing aids, as a preparation for the study with hearing impaired listeners.
Results**:** The objective data of the integrative body responses allowed for a discrimination of the three different hearing modes related to listening effort and listening fatigue when comparing the omni direction to the two directional settings. Furthermore, the combination with behavioral joystick data also allowed for a discrimination of the two different directional modes, showing a benefit when processing the out-field-of-view information differently from the in-field-of-view information (two-hemisphere processing: directional mode 2) instead of just suppressing it (conventional directional microphone settings: directional mode 1).
Conclusions**:** An integrative body response might allow us to disentangle multiple dimensions of listening effort in demanding listening acoustic scenes. The described setup allowed for an objective comparison of different hearing aid settings, demonstrating the advantages of the individual modes for different aspects of the effortful listening situation. In particular, the results suggest that a two-hemisphere processing (directional mode 2) allows to follow an in-field-of-view story effortlessly while not missing information out-field-of-view.

91 - Listening effort in young-adults with different amounts of noise exposure
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Objectives Although noise exposure is often thought of as an occupational hazard, there is growing concern about noise exposure during leisure activities, especially in teenagers and young adults. Excessive noise levels during leisure time can result in hearing damage and/or hearing-related symptoms such as tinnitus and/or decreased sound tolerance, thereby leading to problems with communication and a decrease in the quality of life. Hence, it is important to identify noise-induced symptoms together with their potential impact on the ability to understand speech. In general, pure-tone audiometry is considered the gold standard for hearing evaluation. Besides, other techniques such as otoacoustic emissions (OAEs) and speech-in-noise tests are used to evaluate subjects exposed to noise. In daily practice, however, subjects often indicate that listening in noisy situations is a challenging and often exhausting experience, even in the absence of a clinically significant hearing loss. Hence, a person's perceived difficulty of the listening situation will also be important to consider. Moreover, it has been suggested that beyond the peripheral factors, there are some central cognitive correlates of speech understanding that are essential for communication abilities.
The amount of impact of noise exposure, however, is determined by several factors. For example, the amount of noise exposure as determined by its duration and intensity, are important. Therefore, the aim of the present study was to evaluate the effect of the amount of noise exposure on hearing as measured by pure-tone audiometry and OAEs on the one hand and listening effort measured using a dual-task paradigm on the other hand.

Method The study included 152 adults between 18 and 40 years of age. None of the participants had chronic tinnitus nor a history of known neurological disorders. First, participants completed a self-administered questionnaire regarding the amount of leisure noise exposure (Degeest et al 2017a, 2017b). Second, hearing status was evaluated using pure-tone audiometry and transient evoked OAEs (TEOAEs) as well as distortion product OAEs (DPOAEs). Finally, listening effort was evaluated using a dual-task paradigm, which consisted of a primary speech-recognition task in different listening conditions and a secondary visual memory task that were performed both separately and simultaneously (Degeest et al, 2015). Listening effort was calculated as the change in visual memory performance from the baseline to the dual-task condition.
Based on the quartiles of their subjective estimation of leisure noise exposure, the participants were categorized into a group with low noise exposure (lower quartile), moderate noise exposure (two middle quartiles), and high noise exposure (upper quartile).
Results The groups that were composed did not differ in age, gender and educational level. There was no significant difference in hearing thresholds between the participants with low, moderate and high noise exposure for each frequency of the pure-tone audiometry. In contrast, more absent TEOAEs and DPOAEs were found in the high noise exposed group. Regarding the primary speech-recognition task of the dual-task paradigm, no significant difference in speech recognition was found between the different groups of noise exposure. For the amount of listening effort, it was found that across all listening conditions subjects with high noise exposure expend significantly more listening effort compared to subjects with low and moderate noise exposure.
Discussion and conclusion This study is a first exploration of the effects of different amounts of noise exposure on listening effort showing that, listening effort is increased in subjects with high noise exposure compared to subjects with low and medium noise exposure. The most plausible hypothesis pertains to an effect of noise exposure on the peripheral and central auditory system, or a combination of effects on both the auditory system and the high-level cognitive functions necessary for speech understanding in the subjects with high levels of noise exposure. As such, a test for listening effort would be useful as part of a comprehensive test battery within the assessment of subjects exposed to noise.

393 - Cross-Cultural Adaptation and Validation of the Italian Version of the Vanderbilt Fatigue Scale (VFS)

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Background: Listening-related fatigue can develope in people with hearing loss, mainly in situations in which a listening effort is required. If this effort is prolonged, it may cause negative consequences in different life contexts. Vanderbilt University School of Medicine's researchers designed a questionairre to measure listening-related fatigue named Vanderbilt Fatigue Scale (VFS) (Hornsby, B. W. Y. et al. 2021). The questionnaire consists of 5 sub-questionnaires which analyses the subjective fatigue related to listening, in children (VFS-C), their parents (VFS-P), their teachers (VFS-T) and in adults (VFS-A-40 and VFS-A-10).
Aim: The aim of this study is to translate, cross-culturally adapt and validate the Vanderbilt Fatigue Scale (VFS) in Italian language.
Methods: A written authorization allowing translation into Italian was obtained from the original author. The translation and cross- culturally adaption was conducted following the guidelines of Hall et al. (2018) and ended in September 2021. In order to validate the questionnaire, we have designed an analytical observational study that is still under way. The study involves samples of deaf and normal hearing adults, children, parents and teachers recruited in the Audiovestbology Service of ASST-Sette Laghi in Varese.
Conclusions: Based on preliminary data**,** we currently expect Vanderbilt Fatigue Scale (VFS) to become a valid tool to assess listening-related fatigue in clinical practice.
Key words: listening-related fatigue, listening effort, hearing loss, speech perception, validation, observational study

LISTENING EFFORT (2)

285 - Adverse effects of hearing aid underfitting on speech intelligibility, listening effort and memory for speech

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To verify a hearing aid fitting, clinicians perform real ear measurements to ensure that the gain and output meet prescribed targets for each individual. However, hearing aid users do not always receive the amount of gain they need due to different reasons, such as individual differences in ear acoustic and feedback management in hearing aid. Negative consequences of insufficient hearing aid gain include reduced sound quality and perceived intelligibility. The present study aimed to investigate the effects of hearing aid underfitting on speech intelligibility, listening effort and memory for speech. The Hearing In Noise Test (HINT), pupillary responses during speech recognition and a recall task were used to assess speech intelligibility, listening effort and memory for speech heard in noise respectively. Experienced hearing aid users (mean age = 67 years) with mild-to-moderate hearing loss were recruited. The study had two conditions of gain prescription: 1) a target match condition where the actual hearing aid gain and output were matched to the targets prescribed based on the NAL-NL2 rationale with a 2-dB deviation acceptance and 2) a simulated underfit condition where the prescribed gain was approximately 6 dB below the NAL-NL2 targets between 2 and 4 kHz. Real ear measurements were performed. Expectedly, better HINT performance was found in the target match condition when compared to the underfit condition. The analyses of the pupillary responses showed an increased pupil dilation in the underfit condition, indicating more evoked processing effort when the hearing-aid gain was not optimal. Compared to the underfit condition, the target match condition resulted in a better recall performance for words. The results of the present study demonstrated that underfitting of hearing aids can have negative impacts on perceptual and cognitive processing of speech. This study also sheds light on the importance of providing optimal gain that matches the prescriptive target in hearing aid fitting.
Keywords: speech recognition, listening effort, memory, hearing aid amplification

497 - Quantitative assessment of the influence of sound in affective audio-visual elicitations

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Background: Many studies are related to affective elicitations by means of pictures or video-clips while investigations of reactions to affective sounds are relatively few. Although a soundtrack in video-clips is a part of the stimulus itself, it is not very easy to separate the joint effect of visual and auditory stimulation. In this regard, we set out to investigate through the monitoring of the physiological signal of galvanic skin response (GSR) the role of affective sounds compared to affective pictures.The aim of this study was to investigate if affective sounds can elicit emotions with a minor, equal or higher extent with respect to affective pictures with the same valence and arousal levels and if the joint effect of the two senses by using pictures matched with pertaining sounds amplifies emotional responses in terms of sympathetic activation or deactivation.
Methods**:** 10 subjects were tested. All participants underwent pure-tone audiometry on both ears to be sure that participants were normal-hearing (pure tone average thresholds < 20 dB HL). All subjects with visual impairments were able to use glasses. The protocol was divided in 3 phases in which subjects saw only pictures (P), they heard only sounds (S) and they saw images with background sounds (P+S) pertinent with the content of the pictures. The three phases were randomized for each subject in the order of occurrence. For all the duration of the test, GSR signal was monitored by means of the Procomp Infinity device. Pictures from the International Affective Pictures System (IAPS) and sounds from the International Affective Digital Sounds (IADS) were used. After 5 minute of gray screen visualization, each phase consisted of 4 sequences (S1, S2, S3, S4) of pictures, sounds or pictures with sounds at increasing arousal levels (ranging from 3 to 8) and a median value for valence equal to 5. After each phase, a two-minute gray screen visualization was used to let the GSR signal come back to baseline. In all phases, equal sequences (e.g. S1 sounds vs. S1 pictures) were characterized by equal median value of arousal. In the case of pictures with sounds, the arousal and

valence levels of matched stimuli were around the same. Each sequence lasted 90 seconds (6 stimuli of 15 seconds).
The GSR signal was filtered at 2 Hz with a zero-phase low pass Butterworth of 4th order to remove noise and it was then downsampled from 256 to 5 Hz. A median filter was applied by computing the median GSR of the surrounding samples in an interval of +/- 4 seconds centered on the current sample. The phasic component, linked with sympathetic neuronal activity, was then found by subtracting the median GSR from the raw signal. After finding peak onsets (amplitude > 0.01 μS) and offsets (0 μS < amplitude) on the phasic signal, GSR peaks was found on the raw signal between each onset and offset occurrences. Four basic but relevant features were extracted from the signal in each sequence: the average amplitude of GSR peaks, the number of peaks, the average envelope of the phasic component and the average value of the raw signal. The same features were computed for the last 90 seconds of the three baselines and final features were computed as differences between each feature in the sequence and the same feature in the immediately preceding baseline.
Results**:** The Friedman test (non-parametric and pairwise) with Bonferroni correction indicated statistically significant differences only in S4 for the average peak amplitude between P vs. P+S, for the GSR average between P vs. S and P vs. P+S and for the average phasic envelope between P vs. P+S and S vs. P+S. In particular, for all features highest values were found for P+S and lowest values for P.
Conclusions**:** Statistical analysis shows how differences can be assessed among the three phases only under elicitation of high levels of arousal. In particular, pictures seem to provide the least exciting stimuli, whereas sounds alone and sounds and pictures together seem to elicit similar responses. Overall, we can say that there is a higher sympathetic activation in only sounds elicitation than pictures and sounds together, with lower activation for pictures alone. Therefore, sounds seem to have higher emotional power with respect to pictures, but the joint effect of the two systems seem to amplify single effects. Further research is needed to fully validate the analysis.
Keywords: affective elicitations, sounds, galvanic skin response, IAPS, IADS

Special Session

HEARING IMPAIRMENT AND DEMENTIA: THE SENSE-COG PROJECT TO PROMOTE MENTAL WELL-BEING IN OLDER EUROPEANS

Organized by the SENCE-Cog EU Project

268 - Support care needs of people with dementia and hearing and vision impairment: A European perspective

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Background**:** The care needs of people living in the community with aging-related combined hearing, vision and cognitive impairment are complex and poorly understood. This study aimed to explore the unmet support care needs (SCN) from the perspectives of people with hearing and/or vision impairment in dementia (PwD), and their care partners.
Methodology**:** This was a two-phase mixed-method study: (1) a survey using standardized questionnaires of SCNs and quality of life (QoL); and (2) in-depth qualitative interviews (focus groups or semi-structured interviews). The SCN questionnaire tool was adapted from the long form of the Supportive Care Needs Scale (SCNS-LF59), which was originally developed for cancer survivors. The study took place in community settings in three European countries: UK, Cyprus and France.
Participants**:** The survey included a convenience sample of 40 dyads (person with dementia and their care partner) in the UK, 28 dyads in Cyprus, and 29 dyads in France (9 in Bordeaux; 20 in Nice). For the qualitative interviews, 34 participants (18 PwDs, 16 care partners) were purposively selected across the sites to ensure a representative range of socio-demographic and duration of diagnosis.

Results**:** Over 94% of the participants reported unmet SCNs, with the median number of SCN items being 13 (range 5 to 23). Nearly 75% reported needs in the, moderate to high range. The most prevalent unmet SCNs in PwD were in the psychological (>60%) and physical domains (>56%), followed by the need for health information (i.e. vision, hearing or cognition) in >46%. Both phases of the study revealed that needs were highly individualized. Qualitative themes were: (1) the need for tailored support care interventions; (2) care burden and social isolation and loneliness arising from the combined problems; and (3) the need for adequate support from professionals from the different fields, and specific education in using sensory aids. Associations between SCNs and PwD-related clinical measures were also explored.
Conclusions PwD with sensory impairment and their care partners experience a wide range of unmet SCNs, which impact on QoL. Clinical interventions to meet these needs would address sensory and cognitive domains simultaneously and would be tailored to individual specific needs.

442 - The Montreal Cognitive Assessment hearing impaired version

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Background: Hearing loss is common and commonly go unrecognised and untreated in older adults. Hearing loss a challenge in relation to dementia assessment because it may be difficult to tell how much someone's difficulties are due to hearing loss and how much is due to a cognitive problem. Additionally, tests used to identify dementia are affected by hearing loss, so that someone might do poorly because they have hearing problems rather than a cognitive problem. Some people may end up with an incorrect diagnosis of 'dementia', or the severity of dementia may appear worse than it actually is. Hearing loss may result in people not getting the most appropriate treatment or support. Adaptations of cognitive tests for people with hearing loss have not been adequately validated among people with hearing loss.
Methods: Developed an alternative version of the Montreal Cognitive Assessment (MoCA) for people with acquired hearing impairment, the MoCA-H. The MoCA-H excludes the existing MoCA items that are presented in spoken format and includes new suitably adapted items. The MoCA-H was then validated with people with hearing loss with and without dementia.
Results: Data collection for validation of the MoCA-H was interrupted by the COVID-19 pandemic, although interim ROC analysis completed for this version of the MoCA found the best performance with a sensitivity of 95.74% and specificity of 85.71% for identification of dementia.
Conclusions: An interim version of the MoCA-H has been made available for immediate use by registered researchers via the MoCA.org website. Data collection will recommence, and psychometric data will be updated following completion of data collection once testing restrictions are lifted.

266 - International practice recommendations for the identification and management of hearing, vision and cognitive impairment

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Objective**:** Practice recommendations for identification and management of concurrent hearing, vision and cognitive impairment are non-existent or unrecognized. We will present a first consensus on internationally relevant, multi-disciplinary practice recommendations for professionals involved in the diagnosis, care and management of older people with concurrent cognitive, hearing and/or vision impairment.
Methods**:** The *International Hearing, Vision and Dementia Practice Recommendations' Task Force* consisted of 16 interdisciplinary professionals from Europe, North America and Australia. We adapted core elements of the WHO Handbook for Guideline Development as it allows for flexibility to develop evidence-based practice recommendations considering benefits and limitations of the existing evidence while emphasising the need for individualised professional judgement. Three phases were involved in the development of the guidance, (1) collating existing evidence; (2) filling the gaps in evidence; (3) refining the final list of recommendations. Phases 1 to 3 encompassed various methodologies including a review of existing guidelines within the three clinical domains, systematic reviews, qualitative studies, expert reference groups, clinical professional consortium, and consensus meetings. Recommendations were developed with the contribution of clinical and lay stakeholders.
Results**:** A consensus was reached on 16 recommendations, classified into six domains regarding Awareness and Knowledge, Recognition and Detection, Evaluation, Management, Support and Policy, as they pertain to people with hearing and/or vision loss and dementia.
Conclusion**:** This is the first set of international, interdisciplinary practice recommendations regarding care of concurrent cognitive, hearing and/or vision impairment in older people. The focus of this presentation will be to provide a brief overview of the connections between hearing loss and dementia, followed by a detailed discussion of practice recommendations. These recommendations will help guide audiologists in development of services and policy to improve the lives of older people with dual or triple impairments.

COGNITIVE DECLINE (1)

468 - Hearing Loss & Hearing Care among Persons Living with Dementia: A Unrecognized & Unmet Need in Dementia Care

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Purpose Although dementia and hearing loss are age-related and highly prevalent, relatively little is known regarding the intersection of these two major public health challenges. Basic epidemiology of hearing loss and hearing care among persons living with dementia (PLWD) are limited, particularly in terms of studies that employ audiometric data. Current understanding is largely based on convenience samples primarily from specialized memory clinics that rely on self- and proxy-reported hearing measures. As hearing loss is increasingly recognized as a potentially modifiable risk factor for dementia with hearing care as a potential form of primary prevention, we must also consider the role of hearing care as tertiary prevention of dementia sequela. This presentation will discuss findings from the Atherosclerosis Risk in Communities Neurocognitive Study (ARIC-NCS) is a large, prospective study of a population-based cohort from 4 community sites in the United States (US) with audiometric and neurocognitive testing and bi-racial representation (African American and White older adults). First, we examined the prevalence of hearing loss and hearing aid use among older adults with cognitive impairment and whether cognitive status influences hearing aid use. Second, we assessed the accuracy of self- and proxy-rated hearing status as compared to audiometric data among participants by cognitive status.
Method For analyses related to the prevalence of hearing loss and hearing aid use, we analyzed audiometric and hearing care data from ARIC-NCS Visit 6 (2016-2018). Participants underwent a full neurocognitive battery at visit 6, the same visit at which audiometric data were also collected. Participants with complete audiometric data and an adjudicated diagnosis of cognitively normal, mild cognitive impairment (MCI), or dementia were included in the analytical cohort (N=3,385). The primary reason for missingness was lack of complete audiometric data (N=375). Differences in participant characteristics by cognitive status were descriptively compared using Chi-square tests or one-way ANOVAs. We performed a series of logistic regression models to estimate the odds of hearing aid non-use by cognitive status. For analyses related to the accuracy of self- and proxy-rated hearing status, we examined data from 3,326 self-rated and 520 proxy-rated hearing

assessments. Sensitivity and specificity were calculated, and multivariable logistic regression estimated the magnitude of the association between the concordance of hearing assessments and variables of interest.
Results & Discussion Prevalence of hearing loss was greater with increasing cognitive impairment (cognitively normal:64.7%; MCI:71.3%; dementia:83.3%). Prevalence of hearing aid use among those with hearing loss and cognitive impairment varied substantially by race (African American participants 7.2%; White participants 32.8%). In a multivariable-adjusted model, cognitive impairment was independently associated with higher odds of non-use of hearing aids (MCI odds ratio (OR):1.4 (95% CI: 1.0-1.8); dementia OR:1.8 (95% CI: 1.2-2.9) versus cognitively normal). The strongest risk factor for non-use of hearing aids was race, where African American participants have almost at 5 times higher odds of not using hearing aids compared to White participants (95% CI: 2.9-7.4). For the second question, we found that sensitivity and specificity for self-rated hearing status were 71.2% and 85.9% among cognitively normal older adults, 61.1% and 84.9% among persons with MCI, and 52.6% and 81.2% among PLWD, respectively. For proxy-rated hearing, sensitivity and specificity were 65.7% and 83.3% for persons with MCI and 73.3% and 60.3% for PLWD, respectively. Female sex was positively associated with concordance for self-rated hearing assessments. Overall, our findings demonstrate that hearing loss is highly prevalent but vastly untreated among older adults with cognitive impairment, particularly African Americans. These estimates are some of the first population-based estimates of audiometric hearing loss among older adults from racially diverse backgrounds with adjudicated diagnoses of MCI or dementia in the United States. We found that cognitive impairment was independently associated with hearing aid use and that African Americans with cognitive impairment had the lowest rates of hearing aid use. Furthermore, the low sensitivity of self- and proxy-rated hearing assessments compared to audiometry emphasizes the importance of audiometric assessments among older adults with cognitive impairment.
As our understanding of hearing loss and dementia grows, we must also include individuals with hearing loss who are already aging with dementia as hearing loss is one of the most common co-morbidities among PLWD, frequently goes untreated and unrecognized may be critical to optimizing the health and well-being of PLWD.
Keywords Hearing care disparities, Persons living with dementia, Dementia care, Epidemiology

402 - Auditory behavior of older adults with and without Mild Cognitive Impairment (MCI): Differences in the right ear advantage

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Cognitive impairment is conceived as a continuum that progresses from normal cognition, to mild cognitive impairment, and lastly to dementias such as Alzheimer's disease (AD). Mild cognitive impairment (MCI) is defined as cognitive impairment greater than expected for a person's age (Petersen, 2004). The National Institute on Aging and the Alzheimer's Association describe the clinical criteria for MCI as the following: (1) there must be a general concern regarding the person's change in cognitive function, (2) there must be an impairment in one or more cognitive domains, (3) everyday functional abilities must be maintained with only minimal assistance, and (4) the decline must not be considered dementia.
Studies among older adults suggest that declines in hearing, auditory processing, and cognition are related and that older adults with MCI or dementia have poorer than expected hearing and auditory processing (Gates, Anderson, McCurry, Feeney, & Larson, 2011; Harrison Bush, Lister, Edwards, Lin, & Betz, 2015; Lin, 2011). Our recent study showed that older adults with cognitive impairment show greater difficulty on degraded speech, dichotic, and temporal processing tasks as compared to older adults with normal cognition (Edwards, Lister, Elias, Tetlow, Sardina, Sadeq, Brandino, & Harrison Bush, 2017). Factor analyses indicated that only two domains of auditory processing (processing degraded speech and temporal processing) are unique from cognitive processing and tasks of dichotic processing seem to tap similar abilities as measures of cognition (O'Brien, Lister, Fausto, Morgan, Maeda, Andel, & Edwards, 2020). This led our research team to focus more attention on dichotic tasks of auditory processing as a possible marker of cognitive impairment. We examined the well-documented right ear advantage (REA) for dichotic tasks for two reasons: 1. the nature of the ipsilateral and contralateral auditory pathways and the important role of the corpus callosum for left-ear stimuli, and 2. the documented degeneration of the corpus callosum among those with AD.
The purpose of the present study was to examine 503 cases from our prior research (Edwards, et al., 2017; O'Brien et al., 2020) to confirm previous results and examine the interaction between ear of presentation and MCI status. The older adults (mean age 72 years; range 56-92 years) completed a standard audiometric battery as well as a battery of auditory processing and cognitive assessments over two test visits. The sample was 57% female and 83% Caucasian with an average of 16 years of education, and 31% had MCI. Auditory processing assessments included tests of binaural processing (Dichotic Sentence Identification, DSI; Dichotic

Digits Test, DDT), speech in noise (Synthetic Sentence Identification, SSI; Words in Noise test, WIN), and temporal processing (Time-Compressed Speech, TCS; Adaptive Tests of Temporal Resolution, ATTR). Pure-tone hearing thresholds were indicative of mild high frequency sensorineural hearing loss with three-frequency pure-tone averages (PTAs) falling in the normal hearing range for the majority of participants.
Significant group differences were found for DSI (left ear only), DDT, SSI, WIN, TCS, ATTR, and PTA (*ps* <= .03). A significant group by ear interaction was found for dichotic tests (DSI and DDT; *ps* <= .003) but not for monaural tests (PTA and SSI; *ps* > .9). As the *diotic* tests (TCS, WIN, ATTR) did not include individual ear scores, they were not included in the ear analysis. A much larger REA was found for older adults with MCI than those with normal cognition (12-15% vs. 7%) across the two dichotic tests. Also, the group difference was larger in the left ear (~10%) than in the right ear (2-4%).
These results indicate that older adults with MCI have a much larger REA on dichotic tests of auditory processing than older adults with normal cognition, and this serves to close the gap between the dichotic test scores of older adults with and without MCI. This effect may be related changes in interhemispheric connectivity related to MCI. Indeed, Musiek and Weihing (2011) have shown that left ear deficits are associated with damage to the corpus callosum. Recently, Aylward and colleagues (2021) showed a correlation between left ear scores on the DSI and functional connectivity in the brain among older adults with AD. It is also possible that deterioration of the prefrontal cortex and associated executive functions among those with MCI contribute to attentional dysfunction, which makes processing dichotic information difficult. As prior studies in this area have not routinely presented individual ear scores for dichotic tasks, future studies should focus on the utility of left ear dichotic tests scores as an early indicator of cognitive impairment.

COGNITIVE DECLINE (2)

6 - Exploring the role of social isolation in people living with hearing loss and dementia, in residential care settings

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Aims:

- To explore the mechanisms that contribute to the experience of social isolation
- To record and examine patterns of communication and interaction in residential care
- To give voice to the resident and staff perspective within a care home setting

Residential care settings in the UK currently house 39% of the 750,000 adults over 65 living with dementia (Prince et al., 2014). The prevalence of dementia or mild cognitive impairment in residential or nursing homes can be as high as 80% according to statistics reported by Alzheimer's Society (2014). The prevalence of undiagnosed hearing impairment in individuals residing in care has been shown to be as high as 90% (Tolson and Stephens, 1997). This is therefore an ideal environment to explore potential mediators and consequences of hearing loss and dementia, since a large proportion of older adults with these conditions are residing in care.
The management of hearing impairment and dementia within a care home environment can be very challenging for residents (AoHL, 2018). This can inevitably lead to, or exacerbate, a reduction in social engagement (Wahl and Heyl, 2003). Therefore, an understanding of the context and mechanisms that contribute to social isolation and communication breakdown in residential care settings will provide a theoretical framework for future intervention development to increase social engagement.
The exploration of how social isolation is experienced in care homes was undertaken using ethnographic observations and semi-structured interviews. The purpose of undertaking ethnography was to capture interactions between residents and care staff, and amongst residents, in order to identify the level of social interactions and quality of communication within the home. Part of the ethnographic observations included an environmental audit of each home, as recommended from the Patient and Public Involvement (PPI) preparatory work. Conducting an environmental audit provided formal insight and support for the identified barriers to social interaction in residents living with hearing loss and dementia.
Semi-structured interviews with care home staff and relatives took place to support the ethnographic observations. They were used to identify the impact that a dementia diagnosis has on communication, and how memory and hearing loss together impact communication. Furthermore, the interviews aimed to directly obtain information from stakeholders on their views to improve social isolation within the homes, and attempt to untangle the complex relationship between social isolation and communication.

Participants were recruited from two residential care homes within Birmingham, UK, who specialised in dementia care. These homes were identified as suitable from the initial PPI work. Both male and female residents were included in ethnography and interviews if they were i) permanent residents of the care home, ii) 60 years or older, iii) had self-reported hearing difficulties, iv) had a dementia diagnosis or reported cognitive decline. Care staff who were permanent members of staff and who had sufficient time to participate were invited to take part. Relatives who had a family member that was a permanent resident of the home were also invited to take part. Exclusion criteria included: i) participants who occupied a nursing care bed and were too ill to take part, ii) significant language difficulties, iii) persons unable to provide written informed consent. Across both homes, a total of 16 residents, 11 care staff, and 10 relatives consented to take part in the ethnography and interviews. A grounded theory approach to data collection and analysis was used.Social isolation was experienced in both homes. Contributory factors were the listening environment, the task-focused culture, and general routines within the homes. Meaningful conversation was observed, but exclusion from this was often related to disordered language and non-conforming behaviours.Simple interventions such as staff dining with residents and focussing on improving communication could reduce social isolation within residential care settings. The presence of hearing impairment and dementia were not the crucial factors in the occurrence of social isolation, compared to a resident's language ability and ability to interact.

407 - The evaluation of global cognitive and emotional status of patients with sensorineural hearing loss in middle age

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Objectives**:** Recent literature has supposed sensorineural hearing loss (SNHL) as a concurrent age-related health condition to cognitive decline and frailty in older patients. Nevertheless, SNHL is underestimated in previous age of life although it may be a clinical condition which could alert signs of pre-fragility and Mild Cognitive Impairment (MCI).
The aim of the present study is to identify early indicators for the development of cognitive decline and neuropsychological disorders through audiometry and clinical and neurocognitive assessments in subjects with hearing impairment in middle age.
Materials and methods**:** A multicentric study was carried out at Federico II University Hospital in Naples and at Catholic University of the Sacred Heart in Rome, which began in May 2021 and is still ongoing. It enrolled fifty-nine patients with confirmed diagnosis of bilateral SNHL and twenty-five normal hearing, age matched between 50 and 65 years with no previous otologic diseases and cognitive or neuropsychological disorders. Both groups were submitted to pure tone audiometry, Tinnitus Handicap inventory (THI), Mini-Mental State Examination (M.M.S.E.), Montreal Cognitive Assessment (MoCA), Hospital Anxiety and Depression Scale (HADS-A and HADS-D), EuroQol-5 Dimension (EQ-5D) and Short Form Health Survey 36 (SF-36).
Results**:** The mean age was 58,12±5,42 in SNHL patients and 52,72±4,53 in controls. All evaluations revealed worse results among cases although a statistical significance was detected for MoCA test (p=0.0015), HADS-A score (p= 0.01017) and HADS-D score (p=0.0106). Moreover, 36/59 SNHL patients declared tinnitus with a mild THI score (26,3±29,74) which was directly related to HADS-A score (r = 0.53) and HADS-D score (r = 0.61). Also EQ-5D and SF-36 score showed worse quality of life among SNHL patients, but statistical significant results were found only in these fields of SF-36 score: general health (p=0,035), pain (p=0.042) and energy/fatigue (0.037).
Conclusions**:** Cognitive impairment and psychiatric discomfort should be considered in hearing loss not only in elderly population but also in previous age of life. This study confirm that self-administered questionnaires can be useful in addressing clinical approach.
Keywords: hearing loss, tinnitus, mild cognitive impairment, psychiatric disorders

253 - Post Fitting Assessment of Socialization in Older Adults with Cognitive Decline

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Background Hearing loss is one of the most common health disorders of aging. Multiple studies have indicated that there is a strong association between hearing loss and cognitive function. People who have a hearing impairment tend to socialize less and, as a long term result this could have a negative impact on cognition. Thus, treating hearing loss could slow cognitive decline. The purpose of the present study was to investigate the effects of hearing amplification on the social activity of an elderly group with mild cognitive impairment in Greece.
Methodology A group of 26 older adults, 18 women and 8 men, with a mean age of 74 participated in this study. All participants presented mild cognitive impairment and sensorineural hearing loss bilaterally. In all cases the severity of cognitive impairment was classified with the Greek version of the Mini-Mental State Examination test. All subjects presented noticeable symptoms of dementia such as memory difficulty or word-finding problems, but could still solve everyday problems and take care of themselves. All participants received a complete audiometric evaluation and fitted monaurally or bilaterally with digitally programmable hearing aids of various styles. None of the participants had a previous experience with hearing aids before the time of this survey. They completed the "social skills" subscale of a self-assessment outcome measure for hearing-aid users, the "Amplification Performance Outcome" (APO) that consists of six subscales. They completed it within three to six months post-fitting.
Results Most subjects reported a considerable increase in their social life post fitting, especially in group activities and family relationships. Greater hearing loss and lower speech recognition scores were significantly associated with lower APO scores.
Conclusion Hearing loss is considered the most prevalent sensory impairment in the elderly, affecting communication, thus contributing to reduced social engagement. The findings from the present study revealed a strong correlation between hearing amplification and increased social interaction of the elderly with mild cognitive decline. These findings support the hypothesis that hearing loss in older adults could be a risk factor for cognitive decline. Additionally, identifying individuals with hearing loss and supplying appropriate hearing amplification may have a positive impact on cognition and the quality of life of older people. Future research is needed to identify the associations between hearing loss and cognition, thus providing effective intervention approaches.
Key Words: Hearing Amplification, Cognitive Decline, Socialization, Elderly

430 - Exploring The Prevalence of Undetected Mild Cognitive Impairment in Patients With Hearing Loss

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Background**.** The 2018 NICE guidelines for hearing loss for adults (23) included 'Use of hearing aids and incidence of dementia' as a research priority. The James Lind Alliance Priority Setting Partnership on mild to moderate hearing loss (24) included "Does the early fitting of hearing aids slow the rate of cognitive decline?" as a research priority.
Aims**.** To investigate the prevalence of undetected cognitive decline in patients with hearing loss.
Objectives

1. To look at any demographic characteristics and premorbid factors linked with the two conditions
2. To identify any predictive pattern of hearing loss that may be linked with cognitive impairment
3. To assess the willingness of patients with hearing loss to undergo cognitive testing

Methods**.** Design**:** Parallel group, comparative study.
Intervention**.** *Screening:.* HearCheck™ device[6] for hearing screen
MMSE (mini mental state examination) for cognitive screening
Treatment: Patients who fail the screening test (threshold approximately >25dBHL) will receive a standard audiometric test and offered hearing aid fitting and optimisation. Those who decline HA fitting will be considered for the comparator group.
Support: Online video C2Hear Online www.youtube.com/C2HearOnline [30]
Inclusion criteria

- Age 40 years or older
- Hearing levels of greater than 35dB average in both ears (using air conduction values at 500Hz, 1kHz, 2kHz, 3kHz and 4kHz).

Exclusion Criteria

- Unable/unwilling to participate.

- Age 39 years or younger.
- Any medical or psychiatric disorder that prevents full participation in the study.
- Non English speaking
- Residents of a care home and those with a prior diagnosis relating to cognitive impairment or dementia.
- Existing hearing aid user.

Results
Current Participant Numbers
Total patients invited: 219
Total Declined: 66
Total still to be seen: 118
Did not attend Assessment: 2
Unable to complete hearing assessment
(due to occluding wax for example): 5
Incomplete questionnaires – human error: 2
Non Age related hearing loss group: 15
Age related hearing loss group: 10
Unsuitable to be included due to asymmetry: 3
A total of 219 patients were invited to participate so far from January 2021. Of these 66 declined to participate. So far approximately 31% of patients who were eligible to take part in the study have agreed to do so. To date all patients who have agreed to take part in screening have given results within normal limits.

Many patients who declined did not wish to give a reason for not wanting to take part.
Of those who were willing to give a reason, these included:

- Not wanting to be part of a research project.
- Feeling they had too many appointments for different things and not wanting to have to do anything extra.
- Feeling that they are not good at these types of activities and that this may affect their results.
- Not wanting to know the results.
- Undergoing significant changes in their home life and not wanting anything extra to consider.
- They had not read the Participant information sheet prior to the appointment.
- Uncertainty and wanting more time to consider.

4 - Cognitive Degeneration and how it occurs due to noise effects

Anjan Muhury [1]
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Acquired hearing losses mostly occur as a direct result of noise impact on the auditory systems of humans. These are clearly visible on audiograms, and thus far, hearing aids and cochlear implants have been quite successful in helping hearing impaired people to cope up with aided hearing.
What has also been researched, is the increased prevalence of cognitive degradation during the process of a progressive sensorineural hearing loss which does not display a clear cut etiology, and is variously attributed to diseases in the brain , and/or brain damage.
I propose that sensorineural hearing loss that is progressive and irreversible creates an infusion of mechanical energy in the process of hearing treatment (non-medical), due to deployment of excessive physical forces in the cochlear mechanism and from the neural tracts emanating from the cochlea to the hippocampus in the temporal cortex.
Leakages in the ionic transport and transfer of action potentials takes place in the axonal transportation takes place due to sustained acoustic insults causing nerve leaks, and affecting critical velocities and inconsistency in neurotransmitter sequences in the nerve train delivering variable inputs in the entorhinal cortex that may be sensed as variable values of action potentials at the sub-processing stage. These changes will then alter the locational neurotransmitter adjustments and change the flow of information by re-assigning gating and channeling, thus creating incorrect destinations for the potentials, leading to inaccurate perceptions and processing targets in the hippocampus. The variations also create difficulties in the memory forming mechanisms, and cognitive sequences that have been stored as fixed inputs, and have perception accuracies that remain consistent in the prefrontal cortex, the amygdala, and the CA complex of the hippocampus, which are largely the data fixation points for permanent storage of long-term memory.
Tracking back to physiologic changes: overpressure of sound inputs, means that a lot of extraneous sound needs to be sifted and processed within the scala media, by the duality of inner hair cell and outer hair cell

actions. The myelin sheath begins to degenerate and crack up due to excessive physical pressure that also creates variable 'bloating sequences' within the nerve. Repairs need to be generated with ionic transportation of sodium ions that adds to the internal pressure. Over time the myelin sheath begins to weaken and leaks emanate that reduce conduction velocities from an average of 120 m/s down to 50m/s., and upsets the synchronous rhythm of sound patterns. As hearing loss accelerates the difficulty in sound processing at the organ of Corti, the processing overload at the CA complex is obvious, leading to difficulties in forming new memories, and difficulties in memory interfacing at the prefrontal cortex, leading to memory recall difficulties. Eventually, pyramidal neurons at the CA begin to degrade and memory loss is now a certainty, with dementia symptoms.
It will be understood that the destruction of the myelin sheath, and the cognitive confusion caused by inaccuracies in the action potential sequences lead to cognitive degradation which may be mistaken for age related hearing loss. I have two solutions to hearing aid adjustment and noise reduction technology that I have tried on my patients with significant success. But the degeneration of myelin sheath needs pharmacological intervention, besides hearing aid and CI technology changes.

440 - "Investigation of the Effects of COVID-19 on Perception, Attention, Memory, Balance and Quality of Life in the Elderly"
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Introduction: The impact of the COVID-19 pandemic on mental health in people with pre-existing mental health disorders is unclear. Post-COVID-19 disease causes additional problems such as depression, attention, balance disorders and decreased quality of life in elderly individuals.
Objective: In elderly individuals after COVID-19 disease; To investigate the effects of COVID-19 on balance, perception, attention, memory and quality of life. It is to identify problems such as balance, perception, attention and memory that may be experienced by elderly individuals and to produce rehabilitative solutions for these problems.
Method: In the study, 20 volunteers over the age of 65 who had COVID-19 disease were included as the study group, and 20 volunteers over the age of 65 who did not have COVID-19 disease were included as the control group. After obtaining the demographic information of the individuals, the stroop test for attention, the mini mental test for perception, the digit span test for short-term memory, and the vestibular assessment quality of life test for balance were applied to the participants.
Results: The mean age and standard deviation values of the individuals are 67.2±7.14 years for elderly individuals who have had COVID-19 disease, and the average age for those who have not had COVID-19 disease is 69.3±6.8 years. According to the vestibular assessment quality of life scale ($p < 0.01$), it was found to be significantly associated with perception and attention ($p < 0.05$) and the stroop test ($P < 0.05$). Sensory ($p=0.001$), autonomy ($p=0.008$), past, present, future ($p<0.001$), social participation ($p<0.001$), social participation ($p<0.001$), death seen when compared between groups according to the results of the World Health Organization Quality of Life Scale-The Elderly Module applied to individuals. ($p=0.001$), proximity ($p<0.05$) and total score ($p<0.001$) were significant. Analysis of the Covariance results of elderly individuals with COVID-19 disease revealed that they performed significantly worse on tests of balance, perception, attention, memory, and quality of life compared to elderly individuals without COVID-19 disease.
Conclusion: The negative effects of COVID-19 are also seen in elderly individuals. We are of the opinion that the development of telerehabilitation for the elderly and its effects should be investigated.

COGNITION AND HEARING LOSS IN CHILDREN

61 - Literacy Achievement of School-aged Deaf Students
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The purpose of this study was to investigate the literacy outcomes of a Canadian cohort of school-aged deaf learners. The goal was to establish whether their achievement approached that of their hearing age peers and to identify demographic factors (i.e., gender, type of hearing loss, personal amplification, Categories of Auditory Performance (CAP, Archbold et al., 1995) ratings, grade, additional disability, home language) influencing performance.
Methodology Teachers of the deaf were recruited as participants and shared study information with parents of students on their caseload enrolled in grade four (8-9 years of age) and higher. In addition, teacher participants: 1) completed a questionnaire to document students' demographic information, 2) provided ratings for the CAP index (Archbold et al., 1995), and 3) facilitated assessment session scheduling. Data for this investigation were collected by a team of four certified, experienced teachers of the deaf. Assessments were individually administered to students (N = 74) in sessions lasting approximately 60- to 90-minutes.
While all subtests of the *Woodcock-Johnson III Diagnostic Reading Battery* [WJ III-DRB] (Woodcock et al., 2004) and the two subtests from the Spontaneous Writing cluster of the *Test of Written Language-Fourth Edition* (TOWL-4, Hammill & Larsen, 2009) were administered as part of the larger investigation, data for the present study were drawn from the subtests that comprise the Basic Reading (BR) (i.e., Letter-word Identification [LW], Word Attack [WA]), and the Reading Comprehension (RC) (i.e., Reading Vocabulary [RV], Passage Comprehension [PC]) cluster of the WJ III-DRB.
Results and Conclusions Of the 74 participants, four were unable to complete several subtests of the WJ III-DRB (Woodcock et al., 2004); therefore, analyses were conducted using the data from the remaining 70 students. Data from the demographic questionnaire revealed that 59% (n = 41) of participants were female and that the total cohort was fairly equally divided across three grade bands, including grades 4 to 6 (n = 27), 7 to 9 (n = 26), and 10 to 12 (n = 17). Of the group, 20% (n = 14) had an additional documented disability and 41% (n = 29) a home language other than English.
Of the 70 study participants, 87% had a bilateral hearing loss (n = 61), and the majority (90%) used a personal amplification device, including a hearing aid (n = 45), cochlear implant (n = 13), or bone anchored hearing aid (n = 5). All participants used spoken language as the primary mode of communication and had relatively strong auditory perception skills, as evidenced by CAP ratings of five and higher.
To compare performance with the normative sample, standard scores (M = 100, SD = 15) were used to calculate descriptive statistics for subtest and cluster scores. Using age-based norms, mean standard scores reported for study participants indicated relatively consistent scores across the two subtests, LW (m = 93.20) and WA (m = 95.56), that comprise the BR (m = 94.41) cluster. Mean standard scores were also relatively similar across the three grade bands of participants, including grades 4 to 6 (m = 95.59), 7 to 9 (m = 93.27), and 10 to 12 (m = 94.29). While the mean standard score on the RC cluster (m = 86.07) was slightly lower than the BR cluster, consistency was again noted across the three grade bands of 4 to 6 (m = 87.22), 7 to 9 (m = 83.00), and 10 to 12 (m = 88.94). However, unlike the subtests that comprise the BR cluster, differences were noted across the two subtests of the RC cluster, with a higher mean score reported for RV (m = 91.86) than PC (m = 83.36). The performance of these 70 students stands in stark contrast to reading levels historically achieved by deaf learners, with a median 4th grade reading level (approximately 8- to 9-year-old) reported for students graduating from high school (see Qi & Mitchell, 2012). As growing numbers of deaf children are able to develop age-appropriate language via their hearing technologies, including cochlear implants, studies of literacy development are essential to establish the extent to which children are achieving age-appropriate literacy outcomes. These data will be necessary to create an evidence base for informing educational policy and pedagogical practice.

37 - Executive functions and activities performance in "virtual action planning supermarket" test of children with hearing impairment

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Children with hearing impairment (HI) may have difficulties in Executive Functions (EFs) (Beer et al., 2014). EFs are known to have a significant impact on the ability to perform daily activities. However, the knowledge about EFs in children with HI and its relation to their activity performance is limited. The purposes of this study were to: (1) compare EFs of children with HI as expressed in daily life, based on their parents' reports and on their performance in daily activity as measured by a virtual supermarket with those of children with typical

hearing and development; (2) examine the correlations between parents' reports and child's activity performance among children with HI.
Design: a cross section comparative study and a correlative study.
Method: This study included 38 children with HI and 38 typical children aged 7-12 years (mean=9.25±1.40), 36 boys and 40 girls. EFs were measured by the Behavior Rating Inventory of Executive Function (BRIEF) (Gioia et al., 2000)- a parents' report about children's EFs in daily scenarios. The virtual action planning supermarket test (VAP-S) (Klinger, Chemin, Lebreton, & Marié, 2004) which imitates a whole shopping experience in a supermarket. Due to the abnormal distribution of the parameters, Mann-Whitney was used to examine the differences between the groups in BRIEF and VAP-S scores. Correlations were examined using Spearman correlation test. The level of significance was set on p≤0.05.
Results: In comparison to the control group, children with HI showed greater EFs difficulties according to BRIEF, especially in behavior regulation (Z=**47.47**, *p≤.01*), inhibition (Z=**49.66**, *p≤.01*), and emotional control (Z=**45.82**, *p≤.01*). They also exhibit lower activity performance as measured by the VAP-S and reflected in inefficient planning: longer performance time (Z=**514.63**, *p≤.01*), longer trajectory in the supermarket (Z=**209.64**, *p≤.01*) and more actions that are incorrect (Z=**9.89**, *p≤.01*). Moreover, significant correlations were found between BRIEF and VAP-S score, supporting the concurrent validity of the VAP-S.
Conclusions: Difficulties in EFs of children with HI may be reflected in daily life and affect daily activity performance. In line with the ICF model and family centered approach, intervention should refer to EFs in children with HI (impaired body functions) and understand EFs expressions and impacts on children's activity performance and participation in real life settings. By collecting information from parents and children (while using enjoying platform as the virtual reality), their involvement in therapy may rise, intervention outcomes may be optimized in terms of improving child's EFs, with application on real life context, and by that- enhance child's activity performance, participation , inclusion with peers, and elevate child's quality of life.
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168 - Assessing the Impact of Deafness on Capability

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Hearing loss has a significant negative impact on people's life. In healthcare, assessing this impact and assessing how successful we are in remediating the impact is quite a challenge. Interventions include management of hearing loss, by fitting cochlear implants or hearing aids, and rehabilitation by health care professionals.
Rehabilitation is about supporting (long term) patients to find or regain a mode and level of social participation that enables them to lead a gratifying and satisfying life. This normative concept implies that the patient's aspirations are defined, taking into account his or her personal context, potential, motivation, and interests. In the study presented here, we explored capability, as defined by Nobel Prize laureate Amartya Sen, as a potentially useful concept to assist caregivers and deaf children in defining individual goals and in determining the associated achievements after receiving hearing aids or cochlear implants.
Capability extends beyond an individual's actual functioning by asking what range of valued activities and modes of being are available. The concept of capability as such differs from other available models and instruments in the sense that it aims to establish the degree of freedom a patient experiences or lacks in choosing their own ways of life. In other words, to what extent does a patient's life reflect own choices and to what extent is it determined by factors inherent to individual patients and their social and physical environments? Although capability has attracted extensive interest from a wide range of disciplines globally, its operationalization is still considered a challenge.
We first attempted to evaluate capability in deaf children with cochlear implants through a questionnaire, which we developed based on quality-of-life literature and with input from parents and caretakers of deaf children. The comparison between deaf children wearing cochlear implants and normal hearing children showed that

children with cochlear implants, who perform relatively well on auditory and linguistic tasks, may still experience serious limitations in achieving valued activities and states of being. This is in contrast with results from studies on self-reported quality of life, suggesting that deaf children with cochlear implants are usually on a par with their normal hearing peers.
Although this study showed important outcomes, we encountered limitations in the use of questionnaires to determine factors that support and obstruct capability. Therefore, we used semi-structured interviews, in addition to, standardized quantitative instruments. We assessed capability in children and young adults with cochlear implants and hearing aids, comparing them to normal hearing peers. The preliminary results show discrepancies between traditional functional outcome measures (e.g. speech perception, word comprehension, and phonology) and capability. In addition, the interviews reveal prerequisites for capability in people with hearing loss, leading to opportunities for actions for remediation. Capability offers a new perspective on how the context-specific rehabilitation of hearing loss interventions may be assessed.

HEALTH INEQUALITIES, QUALITY OF LIFE AND HEARING LOSS

65 - The impact of hearing loss on quality of life: development of the hearing-related quality of life questionnaire for Auditory-VIsual, COgnitive and Psychosocial functioning (hAVICOP)

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Introduction: Hearing loss can impact functioning in daily life negatively. The degree of impact of hearing loss on daily functioning is not only related to the decreased auditory input but also to other factors involved in speech processing, e.g. cognitive functions and visual input. Auditory rehabilitation is primarily focused on restoring auditory functions with hearing aids (HA) and/or cochlear implants (CI). However, a large interindividual variability in auditory outcome is observed. Because of this interindividual variability and the multiple factors involved in speech processing, it is important to consider the subjective impact of hearing loss and hearing rehabilitation on the quality of life. The aim of the current study was to develop a new holistic Patient Reported Outcome Measure (PROM), titled the hearing-related quality of life questionnaire for Auditory-VIsual, COgnitive and Psychosocial functioning (hAVICOP), to assess a variety of constructs which affect hearing-related quality of life, including auditory factors, (audio)visual factors, cognitive factors, listening effort and psychosocial factors.
Methods: Initially, a conceptual framework was set up and test items were prepared per (sub)domain. Then, preliminary testing was completed prior to further psychometric evaluation. Preliminary testing involved a semi-structured interview-based assessment in normal-hearing and hearing-impaired adults and an expert panel. For the further psychometric evaluation a new sample of 15 HA-users, 20 CI-users and 20 normal-hearing adults, matched for age, gender and educational level, filled in a digital version of the hAVICOP. Furthermore, the HA users also filled in the Speech, Spatial and Qualities of Hearing Scale (SSQ) [1]. The CI-users also filled in the Nijmegen Cochlear Implant Questionnaire (NCIQ) [2]. At last, both HA-users and CI-users filled in a generic health-related quality of life questionnaire, the TNO-AZL Questionnaire for Adult's Health-Related Quality of Life (TAAQOL) [3]. Based on these results, a factor analysis was conducted. Furthermore, internal consistency was assessed by calculating inter-item and item-total correlations and Cronbach's alpha, discriminant validity was assessed using a one-way Analysis Of Variance (ANOVA) with hearing status (i.e. normal-hearing, HA user, or CI user) as independent variable and the scores for the hAVCIOP as dependent variables. Finally, scores for the hAVICOP were related to answers on the SSQ and NCIQ and the TAAQOL to evaluate concurrent construct validity.
Results: The results of the factor analysis revealed that the test items grouped into three domains, named as 'auditory-visual functioning', 'cognitive functioning' and 'psychosocial functioning'. Furthermore, high levels of internal consistency were found for these three final domains. More specific, an α coefficient of 0.94, 0.92 and 0.94 was found for the domains auditory-visual functioning, cognitive functioning, and psychosocial functioning respectively. Discriminant validity showed significant differences between normal-hearing individuals and HA

users on the one hand and between normal-hearing individuals and CI users on the other hand for the three domains and the total score. Finally, discriminant validity was considered good, with a fair to poor non-significant correlation for the total score of the hAVICOP and the total score of the TAAQOL, for the HA users and for the CI users respectively, and a moderate and very strong positive correlation for the total scores of the SSQ and the NCIQ respectively and the total score of the hAVICOP.
Discussion: The final version of the hAVICOP consists of three domains for hearing-related quality of life: (1) auditory-visual functioning, (2) cognitive functioning and (3) psychosocial functioning. The hAVICOP has a good internal consistency, discriminant validity and concurrent construct validity. In the future, including the subjective impact of hearing loss can lead to more patient-centered rehabilitation based on the individual needs and abilities of the patient. This can give a holistic overview of the impact of hearing loss on individual functioning in daily life and provide a starting point to set individualized rehabilitation goals. The hAVICOP could be used to evaluate the progress throughout the rehabilitation process from the patients perspective.
Key words: quality of life, questionnaire, auditory rehabilitation

39 - The Hearing Health Inequalities Model [HHI Model]: A New Era in Hearing Research across the Lifespan

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Introduction Hearing loss is a major global health challenge, estimated to affect over 466 million people worldwide. However, there is increasing evidence for potentially modifiable risk factors at different life stages that, if eliminated, might prevent or delay hearing loss in later life. To date, audiology lacked a theoretical framework to explain how inequalities in hearing acuity are perpetuated throughout the life-course, which would provide a structure for testable hypotheses and targeted interventions, to reduce hearing health inequalities at many different time points in one's life. Method An online database search (PubMED, Scopus, PsychINFO) was conducted to identify studies in the existing literature in which hearing loss was related to health inequalities, either as a determinant or a health outcome. Fifty-three studies were selected to summarise the existing evidence, using Critical Interpretation Synthesis (CIS) methodology. We utilised established theories of health inequalities to formulate a conceptual model for hearing health inequalities, which depicts the relationship between socioeconomic inequalities and hearing health and the several mechanisms in the evolution of hearing health inequalities over time. Results The synthesis of the available research evidence suggests that: (i) there might be a vicious cycle between hearing loss and socioeconomic inequalities and lifestyle factors; (ii) socioeconomic position (SEP) may interact with less healthy lifestyles to deteriorate hearing ability, (iii) increasing health literacy could improve the diagnosis and prognosis of hearing loss and prevent the adverse consequences of hearing loss on people's health; and (iv) people with hearing loss might be vulnerable in receiving low quality and unsafe healthcare. The Hearing Health Inequalities Model (HHI Model) depicts modifiable factors of hearing loss from childhood to older adulthood and gives insight into the complex mechanisms between socioeconomic inequalities and hearing health. Conclusions**:** The burden of hearing loss, along with the concentration of ill-health among older adults, have highlighted the urgent need to investigate pathways through which socioeconomic inequalities affect hearing health in later life. Most hearing loss cases in adulthood are due to inequalities present in various life stages and perpetuated over time. Tackling socioeconomic inequalities and improving health literacy during the life-course could improve the population's hearing health. Minimising hearing health inequalities is crucial not only for individuals but also for societies, as it affects the social and economic development in communities and countries. These negative impacts arise from the interaction of hearing loss with the wider social environment and can be significantly mitigated through early identification and appropriate management of hearing problems. The HHI Model can be used as a tool for the prevention, identification, and management of hearing health inequalities and for policy formulation aimed at hearing loss risk reduction.

21 - Hearing screening in school-age children from Kyrgyzstan: results of screening and follow-up

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Background According to WHO data, hearing disorders are commonly encountered in school age children. Screening tests have an extremely important preventive role, constituting the primary tool of secondary prevention. Expenditure on early support for child development can contribute to reducing future outlay on health care and social services by eliminating the problem of disability, education deficits and social maladaptation in adult life.
Aim of study The purpose of this study was to evaluate the prevalence of hearing loss in screened children in Kyrgyzstan and referring pupils with positive results to the diagnostic tests.
Material and Methods Prior to testing, the children's parents were informed of the testing procedures and signed a consent form for their children to participate in a hearing screening examination. There were 452 children – 289 (63.9%) 7-8 years old and 163 (36.1%) 11-13 years old. The children attended public primary schools in Bishkek in Kyrgyzstan. Pure-tone air-conduction hearing threshold were obtained at 0.5-8 kHz. Hearing loss was defined as a pure-tone average higher than 20 dB in one or both ears in at least one of the tested frequency.
Results Based on the result of the audiogram, screening showed that hearing impairment was found in 123 (27.2%) of the examined pupils. Information how many out of 123 children with positive results received follow-up testing and intervention services was not available, but we managed to collect follow-up data of 27 children with positive results.
Conclusion It reveals that hearing problems are common in this population. The study has important implications for clinical practice and health policy to introduce low-cost and routine hearing screening. There is need for systematic monitoring of hearing status among children and increasing awareness of parents and educators of the significance of hearing loss.

Technology Update

262 - Benefits of cochlear implantation across the adult life-span

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Benefit from CI may vary according to age and other factors. We collected hearing and quality of life data via Cochlear Sponsored Implanted Recipient Observational Study (IROS) and divided subjects into the following age ranges: 18-34, 35-44, 45-54, 55-64 and 65 and older.
Speech Spatial Qualities (SSQ) scores and Health Utilities Index III scores were collected from 543 unilaterally implanted adults across Europe, South Africa and South America. Audiological data such as the degree of deafness in each ear and hearing history were collected. Additionally, the presence of tinnitus and dizziness were collected at specific timepoints: baseline (pre operatively) and Year 1 ,2 and 3 follow up (postoperatively).
Preliminary analysis shows that SSQ scores varied systematically between age ranges, most notably between subjects aged <45 and those 55 or older. However, gains in SSQ scores between baseline at preoperative visits and Year 1 follow up after implantation were approximately equivalent across age groups and remained stable up to Year 3 follow up.
Gains in Health Utility Index scores were approximately constant across age groups. Dizziness prevalence reduced slightly as did tinnitus pre to postoperatively. Overall, the oldest group had slightly lower levels of hearing loss compared to the younger groups.
Cochlear implantation appeared equally effective in terms of hearing-related quality of life (SSQ) and Health Related quality of life (HUI3) across the adult life span. Overall younger subjects appeared to cope better with hearing loss, either preoperatively or postoperatively. Changes to indications for cochlear implant could be adjusted to allow more severely hearing-impaired younger subjects to benefit.

62 - Evaluation of a hearing aid fitting protocol optimized for active musicians

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Fitting hearing aids for musicians is challenging because there is no universal acoustical model for music. Individual expectations cannot be determined based on previous experience because the combination of music instrument, music type, hearing loss and hearing aid produces highly variable possibilities of listening conditions. While there are some general strategies in hearing aids to optimize the overall sound quality of music, e.g. extended dynamic range or bandwidth and disabled adaptive features, it is difficult to find the optimal frequency response for a given combination of musician (hearing loss and music instrument) and hearing aid (technological possibilities and acoustical coupling). Our assumption is that hearing aid amplification should be optimized with the active participation of the musician during the fitting process to improve their perception of music.
For the present study, 20 hearing impaired active musicians were recruited to evaluate the optimized music protocol against the default music program in a single blinded trial. The optimized protocol is based on a trial and error process involving the active participation of each subject with their instrument. The frequency response is set in such a way to get an even perception of each note across the entire range of the instrument. The effect of the optimized music program, compared to the default music program and the NAL-NL2 based program, was evaluated with the Adaptive Music Perception test (AMP) (Kirchberger & Russo, 2016) in a controlled environment and with a preference questionnaire after a field test.
The AMP test revealed that the default and optimized music programs significantly improve the detection thresholds of pitch, duration, and level over the standard fitting procedure using the NAL-NL2 fitting rationale. While differences between both music programs were not significant in the lab test, the optimized music program was preferred over the default music program after the field test during which subjects had played or listened to music.
These trial results highlight 1) the difficulty and limitations when generalizing findings from a lab test in a controlled acoustical environment to daily life situations and 2) the importance of individualizing the fitting procedure especially for sensitive hearing aid users like musicians. Experience from this trial confirms the need for the audiologist to understand some aspects of music and to use a common language with the hearing-impaired musicians to optimize the technological potential offered by sophisticated signal processing systems.

55 - Optimum Newborn screening techniques for improved outcome measures

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With access to robust technology, performing a newborn screen is accurate, efficient and easy to perform. This however is a small part of the whole screening journey for the babies, families and screeners involved. Together we will look at testing preparation, environment, noise, EEG and impedance; and how this can help screening managers and diagnostic services with population performance monitoring and diagnostic referrals. Looking at our screening protocol on a regular basis is important in our efforts to achieve gold standards of newborn healthcare. Our testing set-up and environment can often affect the durability and outcome of our screening results. Thankfully we have additional data from each screen that can help us with referral types and ongoing performance indicators.
During this talk, we will look at everything optimum probe fit and noise monitoring for AOAE testing, as well as skin preparation and environmental electrophysical interference for AABR testing. Supported with examples of screening monitoring data and test results.

IMPLANTABLE DEVICES

257 - St Thomas' Hearing Implant Centre's Holistic Assessment Model for Potential Bone Conduction and Middle Ear Implant Recipients

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Purpose To share the 'best practice' holistic assessment model used at St Thomas' Hearing Implant Centre for the hearing rehabilitation of potential bone conduction and middle ear implant recipients.

Method and Materials The St Thomas' Hearing Implant Centre offers the full range of surgically implantable devices to rehabilitate hearing including cochlear implants, auditory brainstem implants, percutaneous and transcutaneous bone conduction implants and middle ear implants.
Our service to potential recipients of bone conduction and middle ear hearing implants has seen an exponential increase in referral rate in the past few years. Our model of assessment for this patient has seen a rapid evolution during this time and is based on the belief that device choice should be tailored to each patient, rather than 'assigning' the patient to a device. To do this, it is necessary to take a patient-centred approach when considering the following factors; bone conduction and air conduction thresholds, age, anatomy, co-morbidities, lifestyle and where possible, patient choice of device.
Results The assessment pathway from receipt of referral to consent for surgery will be outlined, detailing the steps taken by the Hearing Implant Centre team, working together with the patient and their family, to reach a device decision. Case studies for the Medel Samba processor with Vibrant Soundbridge and Bonebridge implants and the reasoning behind device choice will be explained.
Conclusion Data regarding patient satisfaction will be shared together with ideas for future development of the assessment pathway.

298 - Transcutaneous Hearing Implants in Children: The St Thomas' Experiences
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Introduction The St Thomas' Hearing Implant Centre provides a full range of hearing implants that include Bone Conduction Hearing implants (BCHI) percutaneous and transcutaneous, Middle Ear Implants (MEI), Cochlear Implants (CI), and Auditory Brainstem Implants (ABI). In addition in 2006, we established the Multidisciplinary Specialist Microtia and Atresia clinic, as a one stop shop to monitor and manage complex patients with craniofacial and ear malformations and hearing loss.
This study was aimed to evaluate the surgical, functional and Audiological outcomes in children implanted with transcutaneous acoustic devices. The devices that were used included the MedEl BoneBridge system, MedEl Vibrant SoundBridge system, Cochlear Baha Attract system, Cochlear Osia system and the Cochlear Carina system. We will discuss our experience in selecting and fitting these systems along with the outcomes.
Material and Methods Patients who were referred for hearing implant assessment underwent the following: a full Audiological work up, language, quality of life and radiological assessment. The questionnaires used were the Children's Home Inventory for Listening difficulties (CHILD), The Speech Spatial and Qualities of Hearing Scale for Parents (SSQ), and Paediatric Quality of Life Inventory (PedsQL).
At the end of the assessment, the Multidisciplinary team (MDT) makes a recommendation appropriate for that specific child. Post-implantation, aided levels, language assessment and questionnaires are carried out to monitor progress and benefit.
Results 14 patients with MedEl Vibrant SoundBridge, 13 patients with MedEl BoneBridge, 18 patients with Baha Attract system, 2 with Cochlear Osia and one with the Cochlear Carina have been implanted so far and the results will be presented. Positive outcomes are seen on the functional, Audiological and subjective outcomes. 2 patients are non-users, and the reasons for this will be discussed. Analysis between devices will be discussed along with aided levels, functional outcomes and questionnaire results. The device selection and decision-making process including Audiological indications, radiological indications and patient preference will also be explored.
Conclusion Correct device selection is essential for good outcomes; patients must have good sound detection as well as a wide output dynamic range for quality sound. Therefore careful audiological candidacy is of the utmost importance.

47 - Outcomes after application of active bone conducting implants
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Background: A bone conducting implant is a treatment option for individuals with conductive or mixed hearing loss (CHL, MHL) who do not tolerate regular hearing aids, and for individuals with single-sided deafness (SSD). An active bone conducting implant (ABCI) was introduced in 2012 with indication in CHL, MHL, and SSD, and it is still the only ABCI available. With complete implantation of the active transducer and consequent intact skin, a decrease in infections, skin overgrowth, and implant losses, all common disadvantages with earlier passive bone conducting implants, could be expected. Our Ear, Nose and Throat Department, a secondary

care center for otosurgery that covers a population of approximately 365,000 inhabitants, was approved to implant ABCIs in 2012.
Objectives: Our aim was to conduct an evaluation of audiological and subjective outcomes after ABCIs.
Method: A cohort study with retrospective and prospective data collection was performed. The first 20 consecutive patients operated with an ABCI were asked for informed consent. The main outcome measures were pure tone and speech audiometry and the Glasgow Benefit Inventory (GBI).
Results*:* Seventeen patients accepted to participate and 15 were able to complete all parts. Six patients had CHL or MHL. In this group the pure tone audiometry tests are comparable with an average functional hearing gain of 29.8 dB HL. With bilateral hearing, the mean Word Recognition Score (WRS) in noise was 35.7% unaided and 62.7% aided. Ten patients had the indication SSD. With the hearing ear blocked, the pure tone average was > 101 dB HL, compared to 29.3 dB HL in sound field aided. With bilateral hearing, the mean WRS in noise was 59.7% unaided and 72.8% aided. The mean of the total GBI score was 42.1 in the group with CHL or MHL and 20.6 in the group with SSD.
Conclusions: The patients benefit from their implants in terms of quality of life, and there is a substantial hearing gain from the implant for patients with conductive or MHL. Patients with SSD benefit less from the implant than other diagnoses but the positive outcomes are comparable to other options for this group.
Keywords: active hearing implant; audiometry; bone-conduction implant; hearing loss; single-sided deafness

107 - Active transcutaneous bone conduction implant: middle fossa placement technique in children with bilateral microtia and external auditory canal atresia
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Objectives Congenital aural atresia is the failure to develop the external auditory canal (EAC) and is often associated with microtia and compromise of the middle and internal ear. It affects 1 in every 10.000 births. Conductive hearing loss is the most common audiological finding.
Treatment options include a functional and an aesthetic approach. Bonebridge (Med-El, Innsbruck, Austria) is an active bone conduction implant that can be placed in the sinodural angle or in the retro sigmoidal position. Since a retro auricular incision (necessary in both approaches) limits the aesthetic pinna reconstruction, the aim of this study is to present the middle fossa placement technique as a surgical alternative in children with bilateral microtia and EAC atresia who cannot undergo traditional surgery for active transcutaneous bone conduction implants (ATBCI) due to their altered anatomy or desire for future aesthetic reconstruction.
Materials and methods A case series descriptive study was designed. The middle fossa technique was developed. Pre-operative and post-operative information from 47 patients with external auditory canal atresia (EACA) and implanted with ATBCI was reviewed.
Results A total of 47 children with bilateral EAC atresia received implants in the middle cranial fossa. Their average age was 11. Of these patients, eight had an associated congenital disorder: Goldenhar Syndrome, Treacher Collins Syndrome, or the Pierre Robin Sequence. The average follow-up was at 30 months (ranging from between one to 84 months). Seven patients showed skin erythema at the processor site after turn-on, which was solved by lowering the magnet strength, and one patient had a scalp hematoma that required puncture drainage.
The hearing thresholds went down on average from 66.5 dB to 27.2 dB one month after turn-on. Speech recognition improved respectively from 29.4% unaided, 88.9% with a bone conduction hearing aid and 96.4% with ATBCI.
Conclusions Middle fossa technique for the active transcutaneous bone conduction implant was proven to be safe and effective for treating pediatric patients with external auditory canal atresia who cannot receive implants at the sinodural angle or in the retrosigmoidal position because of their altered anatomy and/or desire for future aesthetic reconstruction.

COCHLEAR IMPLANTS IN CHILDREN

338 - Cochlear implantation for children under the age of 12-months

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Aim: Cochlear implants (CI) have proven communication benefits for patients with pre- and post-lingual deafness. It has become common to offer CI under the age of one year, once reliable testing is obtained, in order to enable patients to develop their auditory performance and language skills at the earliest possible opportunity[1]. Our aim is to assess the safety and efficacy of cochlear implant surgery in infants under the age of 12 months by reporting surgical[2], anaesthetic[3] and audiologic outcomes and to compare them to children implanted between the ages of 12-24 months.
Additionally, amongst the children in both groups we identified inner ear malformations and other medical conditions or disabilities that influenced complications and outcomes including auditory performance.
Methods: A retrospective chart review of children who underwent cochlear implantation at Evelina London Children's Hospital / Guy's and St. Thomas' NHS Foundation Trust, London, United Kingdom between the years 2000-2020. All patients undergoing CI surgery at ages 0-12 months (group 1) and 12-24 months (group 2) were identified. 47 out of 52 patients in the first group were included, and 67 out of 95 of the second group were included. Patients were excluded due to loss to follow-up, failure to use the device and sequential implantation. Audiometric and speech perception evaluation including: Auditory Brainstem Response (ABR) testing, Category of Auditory Performance (CAP), Speech Intelligibility Rating test and the Nottingham Auditory Milestones (NAMES) were performed. A sub-analysis included data about children from with inner ear malformations to report the complication rates and the final language and hearing ability.
Results: The average age at switch-on was 11.00±2.06 months and 18±3.76 months for group-1 and group-2, respectively. The communication mode one year post switch-on was speech in 71% in group-1 and 55% in group-2, sign language in 2% of group-1 and 7% of group-2 and mixed in 27% of group-1 and 38% in group-2. CAP score was 1.98±1.02, 3.06±1.30, 4.61±1.29, 5.62±1.14, 6.10±1.05 at 3, 6, 12, 24 and 36 months in group-1, respectively. In group-2 the CAP score was 2.05±1.25, 2.89±1.45, 3.76±1.48, 5.13±1.33, 5.45±1.08 at 3, 6, 12, 24 and 36 months, respectively. A statistically significant difference ($p < 0.05$) was noted at the 6 and 12 months post-switch-on time points.
The NAMES score was 22.83±9.44, 42.46±12.57, 59.21±14.5, 68.5±17.25, 78.68±15.65, 87.6 ± 16.81 at 3, 6, 12, 18, 24 and 36 months, respectively for group-1, and 20.19 ± 8.18, 36.38± 12.11, 51.68±19.58, 64.67±22.11, 75.23±16.66, 84.56±13.60 at 3, 6, 12, 18, 24 and 36 in group-2, respectively. A statistically significant difference ($p < 0.05$) was noted at the 6 and 12 months post-switch-on time points.
Conclusion: Cochlear implantation under the age of one year demonstrates comparable safety profile to later implantation. Earlier implantation resulted in favourable outcomes in speech and communication skills comparing to the older group. Further prospective studies are required to corroborate our findings.
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149 - Aetiology, cognition and age-at-implant factors associated with speech perception and language outcomes for children using cochlear implants.

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Objectives: This project utilised a longitudinal clinical dataset to examine the efficacy of early access to cochlear implants with reference to child aetiology factors.

Methods: This retrospective study examined open-set speech perception and language outcomes for 1164 children who received their first cochlear implants between 1985 and 2019. Child, device and family variables (e.g., gender; aetiology of hearing loss; cognitive function; degree of hearing loss; age at hearing aid fitting, age at first and second cochlear implant and a measure of family socioeconomic advantage were collected. Open-set word (CNC words) and sentence scores (BKB Sentences) and language results from criterion based (Rossetti Infant-Toddler Language Scale and Communication Development Inventory) and standardised tools (Peabody Picture Vocabulary Test and Preschool Language Scale) were entered into a database at the time of assessment. Scores derived from different assessments over time, and functional descriptors for children who did not complete formal tests were coded using the Categories of Auditory Performance Index-Revised (CAPI-R; Dettman et al., 2017) and the Categories of Language Performance (CLIP; Dettman et al., 2017).
Results: From 1164 cases, 263 (22%) had no aetiology of hearing loss information in the file, and 182 (16%) were recently implanted, so were therefore excluded from further analysis. Of the remaining 719 cases, 549 (49%) hearing loss aetiology was known and 170 (15%) was unknown (despite completion of all relevant genetic, screening and imaging investigations). From n=549, the 5 most prevalent aetiologies of hearing loss were: Genetic (n=191, 35%); Structural Cochleae/Vestibular abnormalities (n=114, 21%); Meningitis (n=61, 11%); Prenatal, including maternal CMV (n=59, 11%) and Perinatal including prematurity (n=56, 10%). Genetic aetiology was divided into: Family History including Consanguinity (n=87, 16%); Non-Syndromic including GJB2 (n=49, 9%); Syndromic (n=44, 8%); and Chromosomal (n=11; 2%). A subset of these children who received their first cochlear implant before 3 years and 6 months of age was examined and speech perception and language outcomes at school entry were reported. The *mean* open-set phoneme scores for the most prevalent aetiology groups were: Genetic Syndromic=83%; Genetic Connexin=79%; Prenatal CMV=72%; Structural Cochleae/Vestibular=70%; and Prematurity=63%. ANOVA indicated significant differences in *mean* scores for the Syndromic and Connexin groups compared to children in the Premature group. The *median* CAPI-R were: Genetic Syndromic=6; Genetic Connexin=6; Prenatal CMV=5; Structural Cochleae/Vestibular=5; and Prematurity=4. Kruskal-Wallis indicated significant differences in CAPI-R *median* scores for the Syndromic and Connexin groups compared to the Premature group. The *mean* receptive language standard scores (where 100 is the *mean* and a *SD* of plus/minus 15 denotes the normal range for children with typical development) were: Genetic Syndromic=73; Genetic Connexin=81; Prenatal CMV=69; Structural Cochleae/Vestibular=70; and Prematurity=68. Differences in standard scores for children in the Syndromic and Connexin groups were significant when compared to Premature and CMV groups. The *median* CLIP (where the range from 4 to 5 denotes normal language for children with typical development) were: Genetic Syndromic=3; Genetic Connexin=3; Prenatal CMV=2; Structural Cochleae/Vestibular=2; and Prematurity=2. These CLIP *medians* were significantly different for Syndromic and Connexin groups compared to Premature and CMV groups. The above results for the different aetiology groups may be explained by the relatively higher rates of additional cognitive and developmental delays in some of the groups (e.g., the Premature group tended to demonstrate a higher prevalence of cognitive delays). Irrespective of aetiology, optimum outcomes were seen for children with earliest access to cochlear implants.
Conclusions: This unique analysis of a large dataset has enabled the description of communication outcomes for children using cochlear implants for five prevalent causes of hearing loss. The dissemination of accurate clinical data from large scale longitudinal studies can support clinicians' counselling regarding expectations and families' decision making regarding cochlear implants.

148 - Receptive and expressive language trajectories for children receiving cochlear implants before 3.5 years

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Aim: Describe factors affecting language outcomes for children using cochlear implants (CIs), specifically, compare outcomes for children with genetic, syndromic, cochlear/vestibular, or post-natal causes of hearing loss, with/without comorbid diagnoses.
Material and Methods: This retrospective study used two or more language tests completed greater than 6 months apart to derive a receptive (RLT) and expressive language trajectory (ELT) for each child. There were **460** children with congenital/pre-lingual severe-to-profound sensorineural hearing loss who received their first CI before 3.5 years (*mean* age-at-first CI 1.74 years; *range* 0.28-3.49; *SD* 0.78) who completed receptive components of the Minnesota Child Development Inventory (M-CDI), Rossetti Infant Toddler Language Scales (Rossetti), Peabody Picture Vocabulary Test, and Preschool Language Scale (PLS-5). There were **252**

children (*mean* age-at-first CI 1.48 years; *range* 0.28-3.59; *SD* 0.72) who completed expressive components of the M-CDI, Rossetti, and PLS-5. Relationships between dependent variables (RLTs, ELTs) and independent variables were examined; *child development and hearing factors* (aetiology of hearing loss, comorbid diagnoses, cognition), *device factors* (age-at-first CI) and *family/environment factors* (relative socio-economic advantage, communication approach).
Results: The *mean* RLT was **0.81** (*range* -0.22-2.34; *median* 0.80; *SD* 0.41) and *mean* ELT was **0.67** (*range* -0.73-1.96; *median* 0.6; *SD* 0.42) where **1.0** is the goal, and indicates equivalent child language development for each calendar year. Both RLT and ELT were significantly associated with cognition, co-morbid diagnosis, aetiology of hearing loss ($p < 0.001$), age-at-first CI, home and school communication approach ($p < 0.05$). RLT was also significantly associated with socioeconomic advantage and maternal education ($p < 0.05$). Associations were also found between cognition and aetiology of hearing loss ($p < .05$) and between comorbid diagnosis and aetiology ($p < .001$).
Conclusion: Early access to hearing via CIs is a mutable factor that expedites the child's immersion in abundant language models to optimize language growth. Whilst aetiology of hearing loss was associated with language outcomes, the key factors were the presence of comorbid and cognitive diagnoses, not aetiology per se. This result required further unpacking due to significantly higher prevalence of comorbid diagnoses and cognitive delays/impairments in some aetiologies of hearing loss. For example, 88% of children with genetic syndromic cause of hearing loss and 93% of children with a premature birth history had an additional diagnosis. Only 21% of children with a non-syndromic cause and 53% of children with structural dysplasia of cochleae and vestibular anatomy had additional comorbid diagnoses. Clinicians may focus on mutable factors such as facilitating early access to cochlear implants and should encourage the accurate documentation of comorbid diagnosis and cognitive skills, but do not need to have preconceived expectations about language outcomes based on aetiology alone.

360 - Clinical Trial to Expand MED-EL Synchrony Pediatric Indications in the United States
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Introduction: In the United States, obtaining approval from public and private insurers for infant implantation is often challenging. Insurers typically rely upon outdated Food and Drug Administration (FDA) approved indications based on clinical trials done decades ago. In light of ample evidence that early implantation improves language outcome, this situation is an important public health issue. An FDA clinical trial sponsored by MED-EL is underway to expand indications to include infants as young as 7 months. Data from the lead site for this multicenter clinical trial is the subject of this report.
Methods: Prospective study of safety and auditory outcomes of children implanted between 7 months and 5 years 11 months with the MED-EL Synchrony, followed post activation for 12 months. Primary outcome measures: 1. Little Ears Auditory Questionnaire (LEAQ) with score of 25 defined as clinical endpoint; 2. device and surgical related adverse events.
Results: Nine children with severe to profound sensorineural hearing loss were bilaterally implanted at mean age of 8.3 months (range 7 - 16): seven (78%) before 12 months; 4 (44%) before 9 months. No serious unanticipated surgical or device related adverse events occurred. Eight children have completed the study. The LEAQ study endpoint was reached in 6 (75%); 1 (13%) by 3 months, 3 (38%) by 6 months, and two (25%) by 12 months. To date, all children achieving clinical endpoint were implanted before age 13 months. One child not yet meeting clinical endpoint will undergo final 12-month evaluation soon. Two children have completed the study without meeting the endpoint for auditory development. These children were suspected of having autism spectrum disorder based upon lack of expected progress and behaviors. This diagnosis has been confirmed in one, while the other awaits evaluation.
Conclusion: This study adds to literature demonstrating the advantage and safety of infant implantation. Expanding FDA approved age at implantation to 7 months will reduce barriers to early implantation. Lack of expected progress by children implanted during infancy may be evidence of another developmental disorder requiring evaluation and additional intervention.
Key words: expanded indications, infant implantation, safety

394 - Perceptual factors influencing the speech production of children with cochlear implants

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It is a long-held principal of spoken language intervention with children with cochlear implants (CIs) that establishing auditory perception of specific speech characteristics is an important pre-requisite for production. Lowenstein & Nittrouer (2019) argue that the quality of the input signal constrains the speech production capacities of young children. They conclude that the production problems of children with hearing loss can be explained to some extent by the degradation in the signal they hear. Lowenstein & Nittrouer go on to suggest, however, that experience with both production and perception likely plays a role in what speech is finally like. Others go one step further and suggest that in fact, production skills can ultimately have an impact on the development of the ability to perceive certain speech features (for example, Nasir & Ostrey, 2009). Research from my lab examining production accuracy by children with CIs has shown that despite the limited F0 information provided by current cochlear implants, children with cochlear implants are able to produce intonation patterns and stress patterns with F0 patterns that are comparable to that of age matched children with typical hearing (Barbu, Choi, & Mahshie, 2015). Zanchi et al., (2021) reported a similar pattern of comparable production by children with CIs and their typical hearing peers. Mahshie & Larsen (2021) have also found similar production accuracy of contrastive stress for children with cochlear implants and a group of typical hearing peers, although there were some differences in how they achieved these contrasts that are somewhat predictable based on audibility of speech features. A different line of inquiry about perception and production of prosody in children with typical hearing further points to asymmetries between production and perception of prosodic focus in 4-5 year old's with typical hearing (Chen, 2014). Their findings revealed that the ability to produce and comprehend focus were not comparable for all children, and in fact, nearly 1/2 the 14 children examined exhibited better production than perception of focus. There also exist evidence of developmental asymmetries in children with CIs reported by Mahshie, Core, & Larsen (2015) who showed that the ability of young children with cochlear implants to auditorily perceived features such as voicing, vowel height and fronting, and place of production often lags behind their ability to produce these features. This could be the result of instruction, or emerging perceptual skills that are mediated in some way by production. Indeed Mahshie, et al. (2015) reported that changes in perception skills tend to catch up when accompanied by good production abilities. While the importance of auditory perception for speech production development is clear, there is also a significant body of work that suggests that the relationship between production and perception by children with cochlear implants is somewhat complex, and that the bases for perception of certain speech features may not be equivalent for children with cochlear implants and their hearing peers. The purpose of this paper is to examine the evidence for the relationship between perception and production in the acquisition of speech skills in children with CIs, and to offer suggestions concerning both the theoretical, and clinical implications of this evidence. The emphasis of this paper is not to discount the importance of auditory perception and its development in spoken language development, but rather to suggest that the relationship between speech and auditory perceptual skill development is complex, and to examine the importance of additional factors, such as vision, instruction, and the influence of speech production itself on the development of auditory perception. Discussed in the presentation will be the role of these complexities in clinical practice, and the theoretical implications of these findings on current models of the relationship between speech perception and production.

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489 - A study on the association of functional hearing behaviors with semantics, morphology, and syntax in cochlear-implanted preschool children

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Introduction: Monitoring the child's auditory perception, speech, and language development following the programming of the implant is of great importance for the success achieved after implantation. It is often not possible to evaluate children in clinical conditions and the tests used may not provide sufficient information about the functional hearing skills of children in daily life. Therefore, the use of functional hearing scales in addition to clinical tests will provide complementary information about both language development and functional hearing performance of the child. Determining the demographic and environmental variables that affect functional hearing skills and language development will ensure that precautions are taken. The main purpose of this study is to examine the relationship between functional hearing behaviors of preschool children using cochlear implants with semantic, morphology and syntax, and to determine how functional hearing skills and language development are affected depending on demographic and environmental variables.
Material-Method: A total of 48 children (24 girls, 24 boys) with unilateral (n: 14) and bilateral (n: 34) cochlear implants, aged between 3 years and 5 years 11 months, without any additional disability, were included in our study. The Turkish Early Language Development Test was applied to the participants, Functioning after Pediatric Cochlear Implantation (FAPCI), and demographic information form, which evaluates the daily functional hearing skills of children, were filled in line with the information received from the family.
Results: There was a significant relationship between language development and functional hearing ability. It has been found that the duration of implant use, the duration of auditory rehabilitation, and kindergarten attendance have a positive effect on language development and functional hearing skills, and there is a negative relationship between passive screen time and functional hearing skills.
Discussion- Conclusion: The use of scales measuring functional hearing has shown us that there may be a relationship between appropriate listening skills and language development, as well as the knowledge of how children use their hearing in different environments. There are many factors that affect functional hearing and language development that determines cochlear implant success. Determining these factors will provide supportive information in terms of recommendations for successful rehabilitation with a cochlear implant.
Keywords: cochlear implant, functional hearing, language development, semantics, morphology, syntax

122 - Primary auditory outcomes in children with bimodal and bilateral cochlear implants

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Rationale: Nowadays, in children with hearing loss, bilateral stimulation is the standard of care. In many countries bilateral cochlear implants (BiCIs) in children are now reimbursed. Also, audiometric criteria for cochlear implantation have broadened over the years. Children with hearing loss between 60 and 80 dB HL are also considered for implantation. But wat about older bimodal children with moderate-to-severe or asymmetric hearing loss, in which the hearing aid still provides sufficient amplification? The question raises what these bimodally fitted children gain or lose after sequential bilateral cochlear implantation.
Objective: The objective of the study was to gain more insight into the primary auditory abilities of children with significant residual hearing and to define an additional measure to improve decision making when choosing between bimodal fitting or sequential bilateral cochlear implantation.
Methods: Sound localization, spatial release of masking (SRM) and fundamental frequency perception were measured in: i) sequentially implanted children (n=7) who had significant residual hearing prior to second

implantation (i.e. phoneme scores >50% with an hearing aid at conversational level), ii) bimodal children (n=9) with a comparable hearing loss (i.e. phoneme scores >50% with an HA at conversational level), iii) simultaneously implanted congenitally deaf children (n=2), and iv) normal hearing children (n=15).
Localization was tested in a sound-attenuated mobile auditory laboratory with 24 loudspeakers in the horizontal (±70°) and vertical plane (+40/-30°), covered with sound-emitting gaze. Head oriented responses towards the perceived sound locations were measured for broadband, low pass and high pass noise bursts. SRM was tested in two conditions in which the noise location was either moved towards the left or right side. From these two SRMs, a left-right asymmetry in SRM could be calculated. For fundamental frequency perception a just noticeable difference (JND) in fundamental frequency of the nonsense-word /baba/ was assessed.
Results: Group results showed that localization in children with normal hearing was better than children with cochlear implants. Although localization was less variable in children with sequential BiCIs, they only performed better than children with bimodal fitting for the high pass stimulus.
For both the normal hearing children and the simultaneously implanted children, the SRM was symmetric between sides. Compared to normal hearing children, the bimodally fitted children showed a significant asymmetry in SRM. The SRM was significantly smaller when the CI was hindered by noise compared to the situation when the HA was hindered by noise.
There was also a significant correlation between localization and the asymmetry in SRM. As the asymmetry in SRM was larger, the poorer the localization skills were. This was especially seen in children with bimodal fitting. For the prosody test, the CI groups showed significant higher JNDs than the normal hearing children. There was no significant difference between the children with bimodal fitting and the children with BiCIs.
Conclusion: The data hint to an advantage of bilateral implantation over bimodal fitting. The extent of asymmetry in SRM is a promising tool for decision making when choosing whether to continue with the hearing aid or to provide a second cochlear implant in children with significant residual hearing.

COCHLEAR IMPLANTS – ADULTS

73 - A consensus statement on the standard of care for adult cochlear implantation and on the relationship between hearing loss, depression, cognition and dementia

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Objective Globally the number of individuals above 60 years of age is expected to double by 2050, when it is projected to reach over 2 billion. With increasing age comes increasing risk of hearing loss and increasing risk of age-related comorbidities. The objective of this study was to develop a series of consensus statements to provide guidance on best practices for the standard of care for unilateral cochlear implants in adults with severe, profound, or moderate sloping to profound bilateral SNHL. This included several statements on the relationship between hearing loss, depression, cognition and dementia.
Methods A Delphi consensus process was used to generate and validate consensus statements based on evidence identified from the scientific literature. A systematic literature review was conducted to identify studies relevant to at least one of seven key areas: awareness of cochlear implants; clinical pathway for diagnosis; guidelines for surgery; clinical effectiveness of cochlear implants; factors associated with post implantation outcomes; relationship between hearing loss and depression, cognition and dementia; cost implications of cochlear implants. Over three rounds of voting, a panel of 25 international clinical experts on cochlear implants and hearing care was asked to vote on how strongly they agreed with statements on topics of hearing loss and cochlear implantation. The results of the voting rounds were used to develop and refine the statements over the course of the process. The final set of consensus statements are those that had reached the specified threshold of agreement (3 voting times ≥ 75% of participants agree) by the end of the final voting round. During the Delphi process, a CAPAC (Consumer and Professional Advocacy Committee) had a non-voting role,but provided individual comments and feedback from the user and their professional organization's viewpoint on the statements that were taken into account by the Delphi panel chair.
Results The consensus statements provide 20 recommendations on seven key areas of cochlear implantation and hearing health care. Five of the recommendations focus on the relationship between hearing loss and depression, cognition and dementia. These statements confirm that adults with untreated hearing loss can be substantially affected by social isolation, loneliness, and depression. Evidence suggests that treatment with cochlear implants for appropriate CI-candidates can lead to improvement in these aspects of well-being and mental health. Longitudinal studies are needed to obtain further knowledge in these areas. The findings also confirm that there is an association between age-related hearing loss and cognitive function impairment. The

use of cochlear implants is associated with improved cognitive function in older adults with bilateral severe to profound sensorineural hearing loss. Further research is required to confirm the nature of cognitive impairment and the potential influence of hearing treatment in older hearing-impaired individuals. Hearing loss is not a symptom of dementia; however, treatment of hearing loss may reduce the risk of dementia.
Conclusion The consensus statements collectively represent the first step in the development of international guidelines on best practice for CI in adults with SNHL. An international consensus publication is in progress. While associated positive effects of CI treatment for the older adult group are observed as reported in the literature, more well-designed research is called for to help close the evidence gaps and to help refine best practice guidelines further.

319 - Healthy Aging in Elderly Cochlear Implant Recipients: A Multinational Observational Study
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Hearing loss greatly affects quality of life in the elderly population. It is understood that hearing loss may have a cascading effect and interact negatively with physical, cognitive and psychosocial conditions. The primary focus of this study is therefore to evaluate the change in health-related quality of life following cochlear implant (CI) treatment in the elderly. For the secondary objective, it utilizes a full array of assessments to evaluate the impact of CI treatment on healthy aging, including its physical, cognitive and psychosocial domains. The study is designed as a multinational, multicentre prospective study in a large cohort of elderly individuals with equivalent CI experience. 100 first-time unilateral CI recipients at 60 years or above are examined on the full array of evaluations from preimplant to postimplant conditions, i.e. at 12 and 18 months after surgery. The primary indicator of changes in overall quality of life is the Health Utilities Index Mark 3 (HUI-3), whereas the other evaluations consist of details collected through case history and interview questionnaires by clinicians, data logging, self-report questionnaires completed by the recipients and a series of commonly used audiometric measures and geriatric assessment tools. This presentation will describe how these evaluations cover the different domains of healthy aging and will characterize the preoperative condition of the study population. Preliminary data will be presented. The outcomes of this study have the potential to provide crucial clinical evidence on the improvement of overall health status in the elderly through CI implantation and its associated cost savings from a payer and societal perspective.

377 - Improving adult Cochlear Implant users' speech recognition performance in quiet and noise by using predefined fitting parameters
Richard de Quillettes (1) - Marre Kaandorp (1) - Paul Merkus (2) - Sophia Kramer (1) - Cas Smits (1)
Amsterdam UMC, location VUmc, Ent, audiology, Amsterdam, Netherlands (1) - Amsterdam UMC, location VUmc, Ent, Amsterdam, Netherlands (2)

Objectives When patients receive cochlear implants, they undergo an intensive rehabilitation period of several months where settings are routinely checked and adjusted. During these so-called fitting-sessions there are many parameters that can be set. Often, minimum and maximum stimulation levels are set per electrode or electrode group. Most fitting adjustments are based on subjective patient feedback rather than objective measures or objective targets.
Previous research done at Amsterdam UMC identified several fitting parameters that may improve speech recognition in quiet and in noise in adult users of cochlear implants (CI) from Cochlear™. Prediction models were built with speech recognition in quiet and in noise as outcome measures. Thirty tree parameters were considered as candidate predictor variables, including fitting parameters, free-field thresholds, Evoked Compound Action Potential (ECAP) thresholds, and electrode impedances. Electrical dynamic range (DR), free-field thresholds and impedance profiles were found to be significant predictors of speech recognition performance. The results suggest that optimizing these parameters in CI users could result in improved speech recognition. Furthermore, the results can provide audiologists with objective fitting guidelines, and can harmonize CI fitting across centers.

The aim of the current study is to examine whether speech recognition in quiet and noise improves in experienced CI users after adjusting fitting parameters to obtain the model-suggested optimal electrical dynamic range and mean aided free-field thresholds. Further, the role of patient counselling and acclimatization in acceptance of new CI settings is investigated.
Materials and methods A total of 20 experienced adult CI users are included. They are selected on the basis of the expected improvement in speech recognition with adjustment of the parameters. Their mean aided free-field thresholds are at least 27 dB HL and mean electrical DR is below 40 current levels. Mean T-levels will be adjusted so that the expected mean aided thresholds will be at 24 dB HL or below. Subsequently, C-levels will be adjusted to obtain a mean electrical dynamic range between 50 and 60 current levels. Scores for consonant-vowel-consonant (CVC) words and digits-in-noise (DIN) are compared between their standard fitting and optimal model-predicted settings. Patients are given 4 weeks with the new settings to account for acclimatization effects. Finally, subjective benefit of new CI settings are measured using a modified hearing aids questionnaire. Testing will take place immediately after changing the fitting and after the 4 week period.
Results Data collection is still ongoing. To date, 11 patients (9 male, 2 female) aged between 35 and 79 years old (M=68; SD=14) were enrolled in the study. Time since implantation varies between 2 and 8 years (M=3.4; SD= 1.7). We will present results based on 20 patients.
Conclusion We will present data and conclusions on the objective and subjective benefits of optimizing CI fitting parameters objectively according to a model previously determined. Mean T- and C-levels were adjusted to optimize free-field aided thresholds and electrical dynamic range. Additionally, we will discuss the clinical relevance of using target fitting parameters, as done in the present study.
Keywords Cochlear implant fitting optimization

405 - The influence of cognitive factors on speech recognition in cochlear implant users
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Erasmus MC, ENT, Rotterdam, Netherlands [(1)]

Objective: The observed variability in speech recognition of cochlear implant [CI] users cannot be solely explained by auditory and biographic factors. Cognitive factors may attribute to this variability, but no consensus has been reached about its extend and the cognitive processes involved. The current study explored the relations between cognitive factors and speech recognition in quiet and in noise after cochlear implantation.
Methods: Thirty post-lingually deafened adult CI users were tested one year post-implantation using monosyllables in quiet (consonant-vowel-consonant words [CVC]), sentences in quiet and sentences in steady-state noise at a signal-to-noise ratio of +8 decibel[dB]. In addition, participants completed a battery of cognitive tests that measured working-memory (Reading Span test), inhibition-concentration (Stroop color-word test), semantic memory (Verbal Fluency test), declarative memory (Rey's verbal learning test), the ability to read masked text, also called linguistic closure (Text Reception Threshold test) and general cognitive functioning (Mini-Mental State Examination [MMSE]).
Results: The inhibition-concentration ability of CI-users was significantly correlated with CVC word score at 55dB SPL, when corrected for age and educational level [Spearman's rho, ρ=-0.486]. Moreover, the MMSE score was significantly correlated with sentence recognition in noise [ρ = 0.600]. Other cognitive factors were not significantly correlated with speech performance after correction for multiple testing.
Conclusion: Our results support the evidence that cognitive factors contribute to speech recognition performance in CI users and suggest that these factors mainly play a role in more difficult listening situations, like speech in noise or speech at low intensities. Moreover, the MMSE score may not only be useful for screening cognitive decline, but could be informative regarding the expected speech recognition in noise after implantation.
Keywords: cochlear implantation, cognition, speech recognition

369 - The relationship between consistent use of speech processors and auditory outcomes in adult cochlear implant recipients
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The University of Melbourne, Department of Audiology and Speech Pathology Melbourne, Australia [(1)] - Victorian Cochlear Implant program, Royal Victorian Eye and Ear Hospital, Melbourne, Australia [(2)]

Background: Audiologists involved with the rehabilitation of adult cochlear implant (CI) recipients have long suspected that consistent full time use of the devices following surgery is important in reaching optimum auditory outcomes. The advent of data logging for cochlear implant speech processors in recent years has allowed the collection of objective evidence to evaluate this relationship.
Method: Patient files of 149 adult CI users at the Melbourne (Australia) cochlear implant clinic were accessed to extract average hours of speech processor use at 3- and 12-months post-implantation. The latest auditory environment data logs were also extracted, which included average hours exposure to speech in quiet, speech in noise, music and quiet conditions. Correlational analyses were completed between usage hours at 3 and 12 months, and CVC word, phoneme and SRT (Adaptive sentence testing in noise) speech scores, collected within the same time periods. Multiple regression was completed to control for the known predictive variables of age at implantation and duration of severe sensorineural hearing loss.
Results: Average CI use per day was 11.7 hours and 11.5 hours at 3 and 12 months, respectively. Results showed significant moderate correlations between processor usage hours and all three speech perception scores at both time points. The strongest correlations were found between data logging hours and CVC word and phoneme scores at 12 months ($r=0.42$, $p<0.001$ for words, $r=0.41$, $p<0.001$ for phonemes). No significant relationships were found between the proportion of exposure to different listening environments and the speech perception outcomes. Hours of use of the CI processors during the first year following surgery contributed more variance to speech scores than age at implantation and duration of severe sensorineural hearing loss.
Conclusions: These results support the hypothesis that increased hours of CI usage may be important in optimising auditory outcomes for adult CI users. Clinicians should provide all possible encouragement to CI recipients and their families to facilitate consistent use of speech processors. Additional research is needed to investigate the causality of this relationship and to understand the influence of differing auditory environment.

364 - Development of living practice guidelines for cochlear implantation in adults

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Objectives In 2020, consensus statements were published for cochlear implantation in adults with severe to profound sensorineural hearing loss (SPNHL) representing the first step toward the development of international guidelines on best practices. The goal of the subsequent current two year project (October 2021-October 2023) is to create living practice guidelines for cochlear implantation to optimize the care for adults eligible for a cochlear implant (CI). The ultimate purpose of the living practice guidelines it to improve hearing healthcare and CI awareness and to increase utilization of CIs to indicated patients.
Methods An international group of 40 experts, CI users and professionals in the fields of otology, audiology, and hearing care, have been assembled for a Task Force in partnership with the Cochlear Implant International Community of Action (CIICA). Based on scientific evidence from a systematic review of peer-reviewed literature, the Task Force shall create living guidelines for cochlear implantation, focusing on screening, selection, surgery, rehabilitation and after care.
The Task Force, led by 3 co-chairs (Meredith Holcomb, Ángel Ramos Macías and Leo De Raeve), and other stakeholder consultations will drive the development of these guidelines.
Results Developing a consistent approach to optimize the care for adults with significant hearing loss who may not receive adequate benefit from hearing aids will help raise awareness and better define referral and treatment pathways, so patients can receive information about an appropriate treatment option that may help them. The Task Force shall contribute to and support the effective development and subsequent dissemination and adoption into practice of a set of accurate, consistent, and usable guidance and guidelines. For adults with SPNHL, the living guidelines include an accurate diagnosis and timely referral to an appropriate specialist center for assessment and counselling. When it is indicated as the most beneficial treatment option, the patient should be advised by an appropriate healthcare professional about access to cochlear implantation (CI), rehabilitation and aftercare.
Conclusion Living practice guidelines will be developed so they can be adapted and adopted in each country, to optimize the care for adults indicated for a CI. As these guidelines will need to be updated as new evidence is published, the aim of the Task Force is therefore for continuity and evolution over the long-term.

366 - Impact of expanding eligibility criteria for cochlear implantation– A dynamic modelling study of number of cochlear implant recipients, health related quality of life and costs.
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Objectives: Whether a person with severe to profound hearing loss will actually receive a CI is determined by a host of factors, including hearing thresholds which are correlated with speech perception in groups, CI awareness, overall health, the health care system, motivation, culture and emotional and social factors. Eligibility criteria for Cochlear implant (CI) are shifting due to technological and surgical improvements and associated improved outcomes in patients. The aim of this study was to explore the impact of further expanding unilateral CI criteria to adult patients with severe hearing loss (61 – 80 dB) in terms of number of CI recipients, costs, quality of life, and cost-effectiveness from a societal perspective.
Methods: A dynamic population-based Markov model was constructed that mimics the Dutch population in three age categories (40-70, 70-90, 90+) over a period of 20 years. Health states included severe hearing loss (61-80 dB), profound hearing loss (>81 dB), CI recipients and no-CI recipients. Tone audiogram thresholds were used as a proxy for CI eligibility criteria because of data requirements. Model parameters were based on the Rotterdam study, published literature, national databases, expert opinion and model calibration. Health Utilities Index Mark 3 (HUI3) was chosen as primary health outcome. Medical costs and productivity costs of absenteeism/unemployment were included. Probabilistic and univariate sensitivity analysis were conducted to account for parameter uncertainty and parameter influence on model outcomes, respectively.
Results: Model results indicate an increase in total number of hearing-impaired individuals in the Netherlands due to demographic development of 59,6% over a period of 20 years. In this period, there is an estimated decrease in number of persons with severe and profound hearing loss in the 40-70 age category of 7%, and an increase in the 70-90 and 90+ age categories of 63,5% and 120%, respectively. If those with severe hearing loss would qualify and opt for CI in a way similar to those with profound hearing loss, this would lead to a fourfold increase of CI recipients (from 8815 to 35.630) over a 20-year period. The annual number of new CI recipients is estimated to decrease over time and estimated to largely increase due to the expanded criteria. This CI criteria expansion would result in an increase in costs (€ 550 million) and QALYs (54.000), with an incremental cost utility ratio (ICUR) of 10.771,- euros/QALY (2.5 – 97.5 percentiles: 1.252 - 23.171). One-way-sensitivity analysis, to investigate influence of a specific parameter value on the ICUR while controlling for the remaining parameter values, indicated that model outcomes were most sensitive to employment regain, CI utility score, and costs of surgery and testing.
Conclusion: According to the model the absolute number of persons with severe to profound hearing loss in The Netherlands is estimated to increase. If persons with severe hearing loss would qualify and opt for CI similar to those with profound hearing loss now, this would require a substantial increase in operating capacity and associated investment. The results of our modeling study suggest that the associated health gains could be such, that the investment may be considered cost-effective against the backdrop of currently prevailing criteria.
Key words: Hearing loss population, Cochlear implants, cost-effectiveness, dynamic Markov modelling

Special Session
MAKE LISTENING SAFE
Organized by Mark Laureyns and the WHO World Hearing Forum

312 - "The WHO Make Listening Safe" initiative
Shelly Chadha [1]
WHO, Officer Prevention of Deafness and Hearing Loss, World Health Organization, Geneva, Switzerland [1]

The World Health Organization (WHO) estimates that 1.1 billion young people worldwide could be at risk of hearing loss due to unsafe listening practices.
Over 43 million people between the ages of 12–35 years live with disabling hearing loss due to different causes.
Among teenagers and young adults aged 12–35 years in middle- and high-income countries:

- Nearly 50% are exposed to unsafe levels of sound from the use of personal audio devices.
- Around 40% are exposed to potentially damaging sound levels at clubs, discotheques and bars.

How to make listening safe?
There are many actions which can be taken to make listening safe for all. These include measures put in place by individual users, as well as parents, teachers, managers, manufacturers and governments.
Under the theme “Make Listening Safe”, WHO draws attention to the rising problem of noise-induced hearing loss due to recreational exposure to loud sounds.
In this session you will learn more on the WHO initiatives to Make Listening Safe.

279 - Make Listening Safe: The ITU standards on safe listening

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Background According to WHO, about 466 million people globally live with disabling hearing loss due to different causes, and about 1.1 billion are at risk of hearing loss. In particular, an increase in the number of young people with hearing loss worldwide is extremely alarming. In response to this situation, WHO launched its Make Listening Safe initiative in 2015 to educate people on how to enjoy music safely, and since October 2015, has collaborated with another UN agency, ITU (International Telecommunication Union) on standardizing metrics for personal music playing portable terminals (called Personal Audio System; PAS), and developed a new international standard ITU-T Rec. H.870, a WHO-ITU standard for safe listening devices and system.
This presentation introduces the background and technical details of this new international standard. The presentation also touches on other standards from ITU related to safe-listening, one of which is the standard on Personal Sound Amplifier (PSA).
Discussion Temporary and permanent hearing threshold shifts from exposure to sound and noise is an increasing public health problem, particularly in children and adolescents. In fact, sound-induced hearing loss (SIHL) is the leading cause of preventable hearing loss in the world. From the early 1990s to 2000, it was estimated that the number of young people with SIHL has increased from 6.7% to 18.8%. Some of this can be attributed to the fact that in this day and age, young people are utilizing their leisure time with activities that expose them to high levels of music using PAS or attending communal events such as concerts, bars, clubs, etc. Despite this emerging epidemic, there are currently almost no standards set to limit sound exposure in non occupational settings, especially for PAS. This new standard, ITU-T H.870, addresses this standardization gap. The term safe listening refers to listening behaviour that does not put peoples' hearing at risk. A person's risk of losing his/her hearing depends on how loud, for how long and how often the person is exposed to loud sounds. Such exposure may be through personal audio devices or in entertainment venues as well as in the surrounding environment, such as in traffic, in the workplace or at home. This standard specifies the safety standard value of PAS sound volume based on the concept of the Equal Energy Principle, the assumption that the total effect of sound is proportional to the total amount of sound energy received by the ear, irrespective of the distribution of that energy in time. This standard defines the sound exposure dose based on this principle. A unit of sound exposure dose based on sound pressure is also introduced.
This standard is not applicable to the following types of devices:

– two-way communication devices (such as walkie-talkies, etc.);
– rehabilitative and medical devices (e.g., hearing aids, FM systems and other assistive listening devices (ALD) approved as part of hearing aid and cochlear implant systems, etc.);
– personal sound amplification devices;
– professional audio equipment and devices.

The most important aspect of this standard is its recommendation on two thresholds for sound dosage: a weekly threshold for sound exposure level considered safe for adults and that for children. Based on this standard, PAS manufacturers are expected to monitor the weekly sound exposure dose and to warn users appropriately Some manufacturers have already implemented these features.
Another standard, ITU-T H.871, which can be considered a companion standard to H.870, describes safety requirements for personal sound amplifiers (PSA), including both personal sound amplification products (PSAP) and personal sound amplification apps (PSAA). Personal sound amplifiers are non-medical devices

which amplify sounds picked up by a microphone. This device is intended for people with normal hearing and can: a) have a design physically comparable to a hearing aid, in which case it is called personal sound amplification product (PSAP) or b) simply be an application (app) on any smartphone or other device, in which case it is called a personal sound amplification application (PSAA). Currently there is no other international standard for PSAs. Thus this standard is needed to ensure that these devices, which are freely available in the market to anyone, are safe for users and do not further damage users' hearing.

44 - When Your Life and Ears Depend Upon Hearing Protection: the Conundrum of Achieving Auditory Situation Awareness with Protection

John Casali [(1)]
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Prevention of noise-induced hearing loss via hearing protection devices (HPDs), together with concomitant preservation of one's auditory situation awareness (ASA) and vigilance to the surrounding acoustic environment, is critical. Examples include construction workers who wear electronic earmuffs but must hear backup alarms, trail runners who wear attenuating earphones but want to hear bicycles that overtake from behind, emergency vehicle drivers who need hearing protection from the siren but must also hear car horns, and military personnel who wear gunfire-noise-protective headsets but must hear certain signals and speech. The human auditory sense provides key sensory-perceptual inputs for establishing situation awareness, due to the fact that it is always “on” and primed for response, is “omni-directional” and thus reactive to sounds coming from all directions, renders an “acoustic startle response” which provides quick arousal to dangers, and has a relatively low threshold of sensitivity even during sleep. Unfortunately, when the ears are occluded with HPDs or earphones of various types, these auditory capabilities can be compromised. This presentation reviews unique new technologies in hearing protection and attenuating earphone design, which rely on either passive (i.e., dynamically nonlinear acoustic "valves" and filters) or active (i.e., electronically-modulated sound transmission) technologies, that are intended to provide "pass-through" hearing capability. In addition, research results obtained in a series of human factors experiments over the past decade in several in-field and in-lab ASA experiments at Virginia Tech will be covered. These data demonstrate that *certain* augmented devices, including HPDs and Tactical-Communications-and-Protective-System (TCAPS) earphones, in fact do not provide natural hearing or "transparency," and thus can impose deleterious effects on one’s situation awareness. Experimental stimuli have included vehicular warning alarms and a variety of sound signatures of broadband, low-frequency, and high-frequency content. Measures of auditory situation awareness performance have included: hearing threshold at *detection*, accuracy and response time in *recognizing/identifying* and *localizing* signals, and *intelligibility* of communications. Based on these experiments, an objective, repeatable test battery was developed for evaluating ear-occluding device effects on the situation awareness tasks of: **D**etection, **R**ecognition/**I**dentification, **L**ocalization (azimuth and frontal elevation), and **COM**munication, known as "DRILCOM." Example results from this testing, in particular with ubiquitous reverse alarms required by law on industrial-construction vehicles as well as other danger signals, are covered. Also, the interaction effects of HPD attenuation with the low-frequency interaural time difference (ITD) cues and high-frequency interaural level difference (ILD) cues that are so critical to localization are covered. In addition to testing results, research on auditory *training* will be covered, particularly in regard to the ability of the ear to be trained to achieve higher localization performance. Using a unique, portable, azimuthal ring of directional loudspeakers with a dissonant tonal complex that is highly directional, human factors experiments have demonstrated that localization accuracy with the open ear can be improved by at least 30% over baseline, and with *certain* HPDs and earphones, similar improvements can be obtained. However, other HPDs and TCAPS have been found to be insensitive to training effects, giving rise to questions about whether they should be deployed when the user is expected to encounter a sound environment that necessitates auditory situation awareness. The presentation postulates the need for standardized auditory situation awareness testing of augmented HPDs and TCAPS, in similar fashion to Noise Reduction Rating (NRR) and other forms of pure attenuation testing. Furthermore, the implications of users’ perception of auditory situation awareness while wearing HPDs and earphones on their tendency to consistently use such products to avoid noise-induced hearing loss will be discussed.

NOTE: This work received the *"Safe in Sound Award for Innovation in Hearing Conservation,"* awarded by the United States National Institute for Occupational Safety and Health (NIOSH) in February, 2016. See: http://www.safeinsound.us/winners.html
Short Vita & Laboratory Overview: https://sites.google.com/a/vt.edu/john-g-casali-grado-chaired-professor/

Key Words: Auditory situation awareness, sound detection, sound localization, hearing protection devices, TCAPS, earphones, attenuation, hearing perception, hearing training

41 - Effects of training in ear protection use in children

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Children and young adults are often exposed to leisure noise that can harm their hearing. Using hearing protection is warranted in many noise exposure situations and can protect damage to hearing. It is well known that using hearing protection without instruction on the proper method of inserting the ear plugs causes less attenuation than can be gained after instruction. Although many educational projects aimed at school aged children encourage use of hearing protection research is lacking on the ability of the children to independently insert the ear plugs effectively.
In the first project 15 young adults (aged 18-25) and 15 children (aged 10-14) were tested with two different ear plugs (Ultrafit 27 and E-A-R classic). The binaural thresholds to warble tones at audiometric frequencies a meter opposite a loud speaker were measured before and after inserting the ear plugs. Attenuation was calculated by subtracting the threshold without earplugs from that with ear plugs. The ear plugs were inserted twice, once without prior instruction and after instruction and practice of the proper method of insertion. The amount of attenuation gained from the ear plugs was compared between the two age groups, the two types of ear plugs and the various tested frequencies. Results showed that both the adults and the children gained more attenuation after instruction and the children were capable of using both types of ear protection independently.
The second projects aim was to deem if the short instruction given to children aged 10-14 would have a lasting effect. 15 children were tested twice with E-A-R classic foam ear plugs. In the first session they were tested without and with instruction. A month later they were tested again after independently inserting the ear plugs and without any further instruction. The results showed that after instruction the children gained good attenuation from the foam ear plug and the ability to use hearing protection lasted a month.
Our findings show that 10-14 aged children can effectively use foam earplugs for hearing protection. Instruction on proper insertion is necessary in order to gain effective attenuation. A short instruction and practice has long lasting effects. Clinical audiologists should be encouraged to recommend hearing protection and instruct on proper use.

310 - Are we sure we are protecting our ears safely? Evaluation-study of Personal Hearing Protection and Verification Procedures

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Background As audiologists, we are professionally involved in advising and providing solutions for safe listening. In this study we evaluated 7 different types of personal hearing protection, and 4 different verification procedures for hearing protection.
Material and methods Subjects: 41 young, normal hearing subjects (mean age 23 years, 20 male/21 female) participated in this study.
Material: For each subject the following types of personal hearing protection were provided and evaluated:

- 1 set Custom Made Hearing Protection, with 20 dB flat response music filter.
- 3 sets umbrella type instant reusable hearing protection systems with a music filter
- 1 set umbrella type instant reusable closed hearing protection system
- 1 set foam tip instant reusable closed hearing protection system
- 1 set disposable foam hearing protection system

Verification Procedures:

- Audiometric evaluation under headphone at 6 octave frequencies (250 to 8000 Hz)
- Free Field Adaptive Speech-audiometry in Noise at 70dBSPL noise level (BLU list)
- Insertion Gain (REM) evaluation with 65dBSPL and 80dBSPL pink noise
- Leak-test procedure
- Subjective evaluation of Wearing Comfort, Occlusion, Sense of effective protection, Intelligibility of Speech in Quiet, Intelligibility of Speech in Noise, Music Sound Quality, Intelligibility of the lyrics in a song

Results

- The Audiometric Evaluation replicated the specifications provided by the manufactures
- A flat response leads to better perceived intelligibility and sound quality
- Hearing Protection does not have a negative impact on Speech-audiometry in Noise
- Insertion Gain (REM) should not be recommended to evaluate Personal Hearing Protection
- Disposable Foam Hearing Protection has highly variable results, is experienced as very uncomfortable and poor sound quality for music

Conclusions The overall conclusion is that custom made hearing protection with a flat response filter, provides the highest level of user satisfaction, the best intelligibility in noise and the lowest variability in effective protection. Audiometric Verification is recommended over Real Ear Measurements.

Key Words: Personal Hearing Protection, Safe Listening, Verification Procedures.

SURGICAL ISSUES IN COCHLEAR IMPLANTS

208 - Cochlear Implantation - soon a series of robotic processes?

Monika Lehnhardt-Goriany [(1)]
Lehnhardt Foundation, Director of Board, Auggen, Germany [(1)]

In the daily news, which we can hardly escape from any longer, we are flooded with information about technological advances, promising a better future:
Artificial intelligence, augmented reality, smart toys, remote medical /rehab/psychological counseling, smart hospitals, cloud-based collection of patient data, robots as implant surgeons…
I want to share in this presentation my view on where I see the major changes in cochlear implantation.
- CI systems: since the introduction of the multi-channel system in the early 80ies we can see a trend towards continuous miniaturization – implant bodies become smaller and thinner, speech processors become smaller and lighter, some are functioning without cable and coil.
Surgeons can choose from a broad variety of various electrode arrays according to the anatomical circumstances of the individual patient, which can be precisely defined by excellent 3-dimensional imaging.
All CI manufacturers offer new models within increasingly shorter periods of time. For the CI candidate or the family it gets more and more difficult to make „the right choice“ and to manage the technology without constant support from the clinic team. And this is exactly what they want according to a recent study in the UK. So far implants were mainly produced manually, under the microscope, under sterile conditions. It is to be expected that soon robots or cobots will do the job.
It is to be hoped that costs will be reduced and thus CIs will become accessible also for candidates who currently cannot afford it – and these are 80% of the worldwide potential.
- Neonatal hearing screening: The introduction of NHS in the majority of developed countries is an important step towards early intervention, which is crucial regardless of whether the child will get a CI or not. Tracking centers should be established to receive and evaluate data Online. This is how to reduce the rate of „loss-to-follow-up“.
- Early Intervention: Examples of Online EI programmes will be given.
- Surgery: In some countries the CI recipient or the parents can choose the surgeon, which may not be relevant as soon as a robot or cobot will „replace“ the surgeon. Devices like the ARRIscope significantly facilitate the work for the surgeon already now. The development will be gradually and finally the surgeon will be monitoring the procedure and interfere only if necessary – like pilots in aeroplanes.
- Audiological measurements: Intra-operative measurements are done automatically with simple devices already. The feature of data-logging in new models of speech processors, early perceived as „Big Brother is watching you“, has been accepted as a valuable tool for self-evaluation and coaching of parents.
Fitting of speech processors and counseling of CI-recipients / parents is the responsibility of audiologists / engineers. It is very time consuming and with the constantly and exponentially increasing number of the installed patient base and at the same time with the growing lack of professionals' new options to physical sessions have to be found. Fittings and counseling are possible also Online, as proven in many countries with a poor infrastructure, but also practised in countries like Germany, Italy and Poland.
In the future CI recipients will become much more independent by having Apps, which will allow them to do the fittings and adjustments of their speech processor programmes by themselves.

- (Re)Habilitation: The decisive factor for the so-called success for the CI recipient is (re)habilitation. The very young CI-recipients do not really need a lot of what we call (re)habilitation. It is the parents, who need coaching in how to bring their child into the world of hearing, understanding and speaking.
We firmly believe that the Internet (Skype, LiveOnline rooms) will play an increasing role in this field as well. Online coaching courses are already in progress and will be specifically offered to those parents, who have little or no access to professionals locally.
All these technological advances may not only save time and costs but may also free ressources, which only human beings dispose of, and this is empathy which is badly needed not only for babies and small children, but also for teenagers and maybe more and more importantly so for elderly people as well.

267 - Intracochlear Position and Preservation of Residual Hearing Related to the Surgical Approach to the Cochlea in Cochlear Implantation

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In cochlear implantation an optimal position of the electrode array is of great importance, as it may lead to better hearing performance and lower power consumption. In recent years, a slim modiolar electrode has been introduced, the Cochlear Nucleus 532 (CI532). This electrode design is potentially less traumatic compared to previous types of electrodes because of its' dimensions and a position which is further away from the basilar membrane than a midscalar or lateral wall electrode. In our clinic, in a prospective clinical study in 23 patients the cochleostomy approach was used [1]. The electrode position was evaluated per-operatively with fluoroscopy and post-operatively with a ultra high-resolution CT-scan. A significant number of electrode arrays translocated to the scala vestibuli (36%). Preservation of residual hearing was significantly better in the patients in whom the array remained in the scala tympani (n = 15) compared to the patients with translocations (n = 8); mean loss 5 dB versus 21 dB loss, respectively (PTA3).
As a follow-up to the above-mentioned study, we similarly evaluated 23 patients prospectively with the same slim modiolar electrode, now using the extended round window approach only. Participants were 23 adults with severe hearing loss (excluding patients with prelingual hearing loss, obliterative disease, auditory neuropathy) unilaterally implanted with the CI532 electrode at the Radboudumc in Nijmegen. The electrode position was per-operatively visualised with fluoroscopy to rule out a tip foldover. Again, ultra-high CT-imaging was used postoperatively to evaluate the scalar position of each of the electrode contacts. Pre- and postoperative hearing thresholds and speech perception (CVC-phoneme scores) were evaluated.
The average age at implantation was 63.3 (SD 13.3; range 28-76) years and the mean preoperative residual hearing was 81.5 dB. In each of the 23 participants, complete scala tympani positioning of the electrode was achieved. The average absolute loss of residual hearing was 16.2 dB (SD 10.8), corresponding with a residual hearing preservation score (RHP%) of 44% (SD 34.9). The mean post-operative CVC-phoneme score was 72.1% at two months, which further improved to 81.1% at 12 months.
In conclusion, the results seem to confirm the increased likelihood of scala tympani insertion and subsequent excellent levels of speech perception when implanting the Nucleus CI632 via an extended round window approach. However, extending the round window opening was found to be detrimental for residual hearing, emphasizing that there is no 'all-purpose' approach for inserting this particular electrode array.

1. Heutink, F., et al., *The evaluation of a slim perimodiolar electrode: surgical technique in relation to intracochlear position and cochlear implant outcomes.* Eur Arch Otorhinolaryngol, 2019.

COCHLEAR IMPLANTS – STRATEGIES AND FOLLOW-UP

331 - Cognitive measures in cochlear implant counseling and rehabilitation

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Introduction Performance of cochlear implant (CI) users varies widely. CI candidates often have to deal with great uncertainty about outcomes of cochlear implantation. Therefore, it would be of great value if we could more accurately counsel patients on realistic expectations. Many factors affect speech recognition performance with a CI, like duration of hearing loss, fitting parameters, spectral resolution, but also top-down factors like cognitive skills. Including cognitive skills in predicting outcome could therefore improve expectation management.
In our clinic, working memory capacity (measured with the reading span test) and lexical access ability (measured with the visual lexical decision test) are part of the assessment of adult CI candidates. We have demonstrated from post-operative data that these cognitive measures are effective predictors of speech-in-noise recognition, especially when combined with duration of hearing loss. Tentative cut-off scores for the reading span test and the visual lexical decision test were therefore determined to classify CI candidates into two categories: risk or no-risk for below-average speech-in-noise performance. Patients with risk scores are counseled that this may negatively influence their CI performance.
The main goal of this study is to evaluate whether risk scores based on pre-operatively measured cognitive skills accurately predict below-average speech-in-noise performance in CI users, and to formulate suggestions for effective implementation of these tests in the clinic. Moreover, we will compare the results of our data analysis, using pre-operative cognitive data to predict speech-in-noise recognition, to the results that were obtained by analysis of post-operative data in previous research.
Methods A total of 32 patients will be included in our study. Patients complete the reading span test and lexical decision test pre-operatively. Scores for the digits-in-noise and sentences-in-noise test are obtained at 3 and 6 months post-operatively. We will evaluate the accuracy of our risk categories in predicting below-average speech-in-noise performance with CI by calculating the positive predictive value of our categories. Moreover, we will perform correlation and multiple regression analysis, using post-operative speech-in-stationary-noise recognition scores as outcome variable and pre-operative reading span and lexical decision scores along with duration of hearing loss as predictors.
Results To date, 32 patients (18 male, 14 female) are enrolled in our study, aged between 19 and 86 years old (evenly distributed over the age range; M=64.8, SD=13.5 years), with a duration of hearing loss ranging from 1 to 69 years (M=28,3 years, SD=18,4 years). We will present results based on complete longitudinal data from these patients.
Conclusion We will present data and conclusions on the accuracy of our risk categories for cognitive measures in predicting below-average speech-in-noise performance in CI users. Additionally, we will share our clinical experience and provide suggestions for effective implementation and improved category definitions in clinical practice.
Keywords: Cognitive measures, speech recognition, counseling

286 - Social relationships and social communication in adolescents with and without cochlear implants

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Introduction. Adolescents with cochlear implants experience significantly more peer problems, lower peer acceptance, and higher rates of peer victimization than peers with typical hearing. These negative outcomes may result from effects of hearing loss on social skills, but a link between hearing and social communication has not been established. This project explores if auditory status affects social relationships, social cognition, and social perception in adolescents with cochlear implants and with typical hearing.
Methods. Participants include 17 adolescents with long-term cochlear implant experience (M=13.9 years) and 32 adolescents with typical hearing (M=13.7 years). All participants completed (a) the pragmatic subtest of a formal language test; (b) an online survey including measures from the Emotion Domain of the National Institutes of Health Toolbox for Assessment of Neurological and Behavioral Function (i.e., social relationships); and (c) tablet-based measures of emotion recognition and social perception from the Pediatric Evaluation of Emotions, Relationships, and Socialization (PEERS).
Results. Auditory status did not affect emotion recognition ability. The adolescents with typical hearing achieved significantly higher accuracy and faster response time than the adolescents with cochlear implants on the social perception task ($p<.05$). On the National Institutes of Health Toolbox Emotion measures, the typical hearing group reported (a) significantly more positive ratings of friendship and emotional support; and (b) significantly lower levels of perceived rejection compared to the group of cochlear implant users ($p<.05$).

No significant group differences emerged on the National Institutes of Health Toolbox loneliness instrument. Measures of social communication significantly correlated with pragmatic skills and ratings on the social relationship questionnaires ($p<.05$). Results will be described in terms of risk and protective factors related to social communication and social relationships in adolescents with cochlear implants and adolescents with typical hearing.
Conclusion. Adolescents with cochlear implants exhibit poorer social perception and social-pragmatic skills and report significantly less positive social relationships compared to peers with typical hearing. These results highlight the need for additional services or support for adolescents with hearing loss who experience peer problems, and provide the first step toward development and implementation of evidence-based therapy targeting risk and protective factors to effectively reduce social communication deficits in adolescents with cochlear implants.

432 - Borderline Candidacy: too bad for a conventional hearing aid and too good for a Cochlear Implant

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Background: Fundamentally, if we don't understand the benefits and limitations of a hearing intervention, we are prevented from ensuring that those who could benefit are given the CHOICE to consider it. This is especially true for cochlear implantation (CI) in individuals with borderline candidacy, such as those with potentially useful residual low-frequency hearing. EQUITABLE access to CI requires clear understanding of the impact of the intervention in those with demonstrable benefit from acoustic amplification of residual hearing. We should not wait for the child to fail, but rather challenge ourselves to consider if they could be doing better. The benefits of combined electrical (CI) and residual hearing include improved speech discrimination and interpretation of speech features such as stress and intonation, music perception and access to binaural cues. However, the literature fails to provide evidence regarding the specific benefit of acoustic hearing in addition to electric stimulation in complex listening. To aid this, postoperative testing of hearing preservation with cochlear implantation (HPCI) recipients in the CI-only setting versus CI + acoustic hearing setting is required. More specifically, postoperative tests reflecting day-to-day listening are necessary to establish the added value of hearing preservation. Furthermore, if the UK NICE (TA166, 2019) guidelines stipulating that hearing loss must be bilateral are adhered to, children & young people (CYP) that have one ear within CI audiological criteria, who could benefit from CI and binaural hearing, won't receive CI. Yet the literature concerning this is scarce. An understanding of "real-life" audiological performance of CYP with different hearing modalities on various audiometric domains is essential.
Objectives: 1) Perform a systematic review evaluating the levels of successful HPCI. 2) Report our experience of HPCI in a paediatric cohort. 3) Perform a systematic review to determine the "real-life" benefits of HPCI.
Methods: 1) Inclusion criteria for systematic review were HPCI recipients < 18 years with Slim-Straight-Electrode (SSE) or similar electrode. Exclusion criteria were non-English language, conference abstracts, reviews, animal and cadaveric studies, no specific paediatric data, pre-operative thresholds >80dBHL at 250Hz and electrode used >20mm. The tool of the Evidence Project was used for risk of bias assessment. 2) A retrospective case note review of sequential paediatric HPCI cases in our CI centre between 2016 and 2019 using a 'soft surgery' technique, Cochlear Nucleus® SSE, pre-operative hearing thresholds <80dBHL at 250Hz. The primary outcome was hearing preservation based on unaided postoperative hearing thresholds using the HEARRING group formula. 3) Inclusion criteria for systematic search were the "real-life" benefit of HPCI. Exclusion criteria were non-English language, conference abstracts, reviews and animal and cadaveric studies. Risk of bias was assessed using the Evidence Project Tool.
Results: 1) Thirteen papers were included (8 SSE vs 5 other electrode). Hearing preservation rates for the SSE vs similar electrodes were 32-100% vs 33-100% – HEARRING formula and between 63-100% vs 0-100% – functional hearing. 2) We report HPCI rates of 78% and 93% respectively for our group of 25 patients. 3) Thirty-seven studies were included with 8/37 including children and 29/37 including adults. HPCI was associated with better speech perception in noise in 18/26 papers and better music perception in 4/5 papers. There was no significant benefit reported in speech perception in quiet (14/20 papers) or binaural cues (3/4 papers), nor was there evidence of HPCI outperforming bimodal users (5/7 papers). QoL scores were high

amongst HPCI patients (2/2 papers). Interpretation was hindered by small study groups and significant heterogeneity.
Conclusion: 1 and 2) Our data showed that we have reliably achieved clinically meaningful hearing preservation in most of our patients. The literature confirms that it's possible to preserve hearing using the SSE, although success rates vary. Due to heterogeneity in outcomes, no definitive conclusions can be made regarding performance of the SSE versus other comparable electrodes. The field of HPCI would benefit from unification of outcome reporting to optimize evidence available to professionals, patients, and carers. 3) Literature on the "real-life" benefit of HPCI, supports the existence of meaningful benefit, especially in speech perception in noise and music perception. However, outcomes vary between studies and there is significant heterogeneity in parameters. Our evolving understanding of optimal programming settings and interpatient differences should lead to a strategy complementing individualised patient needs and care.

169 - Underspecified Phonological Representations in Teenagers with Cochlear Implants
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Verbal working memory is defined as a temporary storage mechanism with a limited capacity, consisting of a short-term storage component and a processing component (Baddeley, 1974). Recent findings in literature suggest that verbal working memory is an important predictor for speech perception (Akeroyd, 2008). In addition, working memory problems found in children with cochlear implants are more likely the result of storage than processing problems (Cleary et al., 2001; Nittrouer et al., 2013). The reduced working memory skills may in turn have a negative influence on speech perception and spoken word recognition (Pisoni et al., 2011).
Several studies have already provided evidence that prolonged hearing loss can cause degeneration of long-term phonological representations. As a result of the degraded auditory input, profoundly hearing-impaired patients had underspecified phonological representations. Moberly (2016) has shown that cochlear implants do not adequately restore those representations. As a result of these poorly specified phonological representations, the efficiency and capacity of their short-term working memory may be reduced.
This leads us to expect children with cochlear implants to have decreased verbal working memory capacities, disrupting the development of phonological and linguistic competence. 35 prelingually children with cochlear implants participated in this study. Their average age was 14 years, ranging from 10-18 years. Age at implantation was relatively high; 42 months on average. The following assessments were carried out: speech perception by phoneme recognition at 70 dB SPL in quiet and in noise (SNR=0), phonological processing with a nonword repetition task, verbal working memory with forward and backward digit span tests, linguistic abilities with a receptive vocabulary test and a sentence repetition test.
Although the results show adequate speech perception in quiet, even in relatively favourable SNR environments speech perception scores decrease dramatically for children with cochlear implants. Their phonological processing abilities were inadequate as well. Remarkably, verbal working memory showed a deviant profile; forward repetition performance was very poor, whereas backward repetition yielded normal outcomes. This reflects difficulties in the storage component of verbal working memory. The phonological and verbal working memory challenges are associated with linguistic competence. The outcome, theoretical construct and the implications for rehabilitation and education will be discussed.

458 - Identification of safety-relevant environmental sounds by cochlear implant users
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Objectives: Improved perception of environmental sounds in the listener's daily life is generally considered among the main benefits of cochlear implants (CI). Environmental sounds provide listeners with information about what is happening in their surroundings. The ability to accurately identify sources of many common

environmental sounds such as car honks, cries, glass breaking or fire alarms has important safety implications. Although research in this area is relatively sparse, existing studies indicate that identification of environmental sounds (ESI) generally remains mediocre following implantation. Even after several years of implant experience average ESI performance remains comparable to that of CI candidates and is substantially reduced compared to normal-hearing (NH) peers. Furthermore, our retrospective data analysis indicates that CI users also struggle with identification of safety-relevant sounds, which could be defined as "biological, mechanical, or electronic auditory signals that are potentially important for maintaining one's well-being, avoiding real or perceived harm or other undesirable circumstances." Safety-relevant sounds arguably constitute the most important subset of all sounds in the listener's environmental, with the exception of speech. The purpose of the present study was to conduct a prospective investigation of the ability of CI users to identify common safety-relevant sounds.
Method: Participants were 20 adult (ages 25-87 years) postlingual CI users with at least three years of CI experience. Participants heard 42 common environmental sounds, 28 of which were considered safety-relevant (e.g., car skidding, gun shots, police siren), while 14 other environmental sounds were considered as non-safety relevant controls (e.g., wind chimes, guitar playing, yawning). These test sounds were identified with high accuracy (>95% correct) by NH peers. After each sound was presented, participants selected the most appropriate name for the sound from those displayed on the screen. Prior to sound identification, participants were shown sound names and asked to rate the familiarity and, separately, relevance to safety of each corresponding sound on a 1-5 scale.
Results: Overall mean ESI accuracy was 56% (SD = 20%). No significant differences were observed between ESI accuracy for the safety-relevant sounds, 57% (SD = 19%), and control environmental sounds, 55% (SD = 25%). Participants rated safety-relevant sounds as more important to safety than the non-safety sounds, 3.93 and 1.95 respectively, and also as more familiar, 3.98 and 3.63, respectively. There were significant ($p < 0.05$) moderate correlations between familiarity ratings and identification accuracy for both safety-relevant ($r = 0.53$) and non-safety relevant sounds ($r = 0.56$). No significant correlations between duration of CI use, listening modality, etiology of hearing loss, pure tone averages or word recognition scores and ESI were observed. However, there was a significant correlation between ESI accuracy and participants' age ($r = 0.52$)
Conclusions: Consistent with earlier research, the present findings indicate suboptimal ESI accuracy in experienced adult CI users for safety-relevant as well as other common environmental sounds. Inability to accurately identify many common safety-relevant sounds may put CI listeners at increased risk of accidents or injuries. A rehabilitation program specifically targeting perception of common safety-relevant sounds may be considered in order to improve individual safety and increase CI benefits to individual implant users.
Keywords: cochlear implants, environmental sound perception, safety-relevant sounds

234 - Factors affecting speech recognition performance in quiet in adults with cochlear implants
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Introduction Since the introduction of cochlear implantation (CI) in the early seventies, CI-technology and knowledge regarding surgery and fitting have continuously developed, leading to improved performance with CI. Despite this overall improvement, performance still varies across CI recipients. Several studies have shown that the degree of functional residual hearing, pre-implantation, is correlated with CI performance (e.g. Gomaa et al., 2003), others found a relation with, among others, biographic factors (e.g.Blamey et al., 2013) and electrode position factors (Holden et al., 2013). After controlling for age, Holden et al., found several electrode position related factors (scalar position, angular insertion depth and wrapping factor) significantly correlated with speech perception. In many studies, however, the effect of type of electrode was not included, or corrected for. This might have introduced a bias (Heutink et al. 2019). In current study, we investigated in two types of electrodes (precurved and straight) the effect of biographic, audiologic and electrode position related variables on speech recognition performance in both quiet and noise.
Method Adults (N=129), willing to participate, with a post-lingual onset of deafness and normal cochlear anatomy and implanted at the CI center of the Radboud university medical center in Nijmegen, were included in this study. These participants were implanted with either a precurved (CI512/CI24RE; N=85) or a straight (CI422/CI522; N=44) electrode of the Cochlear CI system. The included variables were: 1) biographic variables (age at implantation, level of education, years of hearing loss), 2) audiologic variables (preoperative and

postoperative residual hearing, and preoperative speech perception) and 3) electrode position related variables (scalar location, electrode type, insertion depth and electrode-to-modiolus distance). All subjects participated in a cross-sectional study, involving imaging and performance evaluation. Post-implantation, the electrode position was visualized on an ULTRA high-resolution CT-scan. These imaging data were analyzed using "Matlab" software. Speech perception was measured with CVC –wordlists in quiet at 55 dB at >12 months post-implantation. For each variable, differences between the precurved and the straight electrode were calculated and tested using t-tests or Mann-Whitney U tests. A multivariable linear regression model was conducted to investigate the influence of type of electrode on CVC55 speech perception score, corrected for the influence of biographic, audiometric and other electrode positional factors.
Results Results showed that implanting a precurved electrode instead of a straight electrode increases speech perception in quiet with 11.8% (95% CI: 1.4 – 20.4; p=0.03) independent of biographic factors, audiometric factors and scalar position of the electrode. This result might be explained by the most distinct difference between the precurved and straight electrode which is the position towards the modiolus. Precurved electrodes were placed significantly closer to the modiolus (p<0.001) compared to the straight electrodes. In addition, there was a trend for a positive influence of lower age and higher pre-operatively hearing at implantation. Other biographic factors or other electrode positional factors did not independently influence speech perception.
Conclusion Cochlear implantation with a precurved electrode (having a smaller wrapping factor and deeper angle of insertion) results in higher CI speech perception outcome; independent of biographic factors, audiometric factors and scalar location. Univariable analysis of biographic, audiometric and electrode position factors affecting speech perception is strongly influenced by correlation between the independent factors of interest, and this confounding bias should be accounted for in all observational studies investigating cochlear implantation.
Keywords: Cochlear Implant; Imaging; Electrode position; Explanatory Factors; Speech Perception

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417 - Place-pitch discrimination over the full electrode array
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Objective: To investigate variations in place-pitch discrimination along the electrode array and to validate an improved version of our earlier published full-array pitch discrimination test.
Materials and methods: We tested twenty-five adults implanted with a cochlear implant (CI) from Advanced Bionics, mainly HiRes90K MS. All subjects had at least 6 months experience with their CI. The subjects performed two different psychophysical experiments on place-pitch discrimination. In both experiments, subjects had to identify one stimulus (probe) as being the odd-one-out compared to two reference stimuli, according to a three-alternative forced choice (3AFC) task. The reference stimuli were stimulated at the physical contact of interest and probe stimuli were created using simultaneous dual electrode stimulation (DES), also known as current steering. In the first experiment, three channels were measured, pre-determined (using multi-slice computed tomography) at 120° (basal), 240° (middle) and 360° (apical) from the round window. On these three channels, pre-defined inter-channel distances (ICDs) ranging from 2 (physical electrode contact distances) to 0.1 (DES, α=0.1) were tested, with 12 trials each. Psychometric functions (PF) were fitted with MATLAB resulting in the Just Noticeable Difference (JNDα), defined as the threshold at 66% correct. In the second experiment, subjects completed a pitch-discrimination task on every channel of the electrode array. This test used four discrete ICDs: 2, 1, 0.5 and 0.25. After five repetitions on the 'easiest' probe condition (ICD = 2) the score was evaluated, if ≥3 out of 5 repetitions were correct the ICD was decreased for the next round. The final discrimination score (Dα) was defined as the lowest ICD where at least a score of 80% (≥4 out of 5) was met. Lastly, we compared the subjects' channel discrimination results with

their speech perception scores, using free-field consonant-vowel-consonant phoneme recognition scores as measured during the subjects' regular clinical program.
Results: Twenty-four subjects completed the PFs for all three tested regions, while one subject completed only middle and apical PFs. The average JNDα across all subjects was 0.65; there was no significant difference between JNDα per region. The JNDα and Dα scores varied widely between subjects. The easiest probe condition, ICD = 2, was distinguished on almost all tested channels. Both tests took approximately equally long to complete (±45 minutes). However, in that time frame only 3 contacts could be tested with the PFs, while the whole array was examined with the full-array test. To compare the PF outcome (JNDα) with the full array test outcome (JNDα) measured on the same channel, JNDα scores were grouped by their corresponding Dα scores 0.25, 0.5, 1 and >1. All groups were significantly different from one-another. Spearman's rank correlation indicated a significant positive correlation between JNDα and Dα score measured on the same contact (r_s = 0.64, p < 0.001). Moreover, linear correlations showed a significant relationship between JNDα and speech perception score in quiet (speech at 65dB and 75dB SPL) and in speech in noise (speech at 65dB SPL, SNR +10dB).
Conclusions: The significant relationship between JNDα and speech perception score indicates that pitch discrimination ability could be a useful parameter in clinical fitting. Furthermore, we identified a significant correlation between the gold standard JNDα and novel Dα outcomes. The full-array test distinguishes between pitch discrimination performance, in approximately the same time it takes to measure three more accurate PFs (±45 minutes).
Key words: Cochlear implant, place-pitch discrimination, speech perception, psychophysics

464 - A qualitative investigation of barriers and facilitators to early cochlear implantation in children
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Aims This research aims to identify barriers and facilitators to early cochlear implantation for children with congenital hearing loss, in a universal healthcare context, whose parents and carers have made the decision to be referred for cochlear implants. Objectives were to explore parents and professionals' views and opinions on the factors that influence decisions about cochlear implants, and to examine the process to cochlear implantation from the perspective of both parents and professionals.
Methods We took a qualitative approach and used grounded theory methodology. We used qualitative interviews with both parents, carers and professionals who are involved with the cochlear implant process in the UK. The researcher asked parents to describe in their own words their experiences, actions and decision making from identification of their child's hearing loss, up to cochlear implantation or the present date if they had not yet had cochlear implants. For professionals, the researcher asked them to describe in their own words their experiences and thoughts on the decision-making process to cochlear implantation, and what helps or hinders time to implantation. We also used ethnographic observations of a cochlear implant assessment clinic, and the researcher aimed to describe and explain the phenomena under investigation. The study sample comprised 12 families, and 6 professionals.
Findings The phenomena at the core of the process for parents is the work generated by the cochlear implantation process, including the work given by healthcare services and the emotional coping of parents around their child's newly identified hearing loss and the potential of cochlear implants. The pre-condition to this phenomenon for parents is the degree of disruption to life caused by deafness. The process of cochlear implantation occurs within the context of the family's life, and parents use a range of strategies to integrate the work required as part of the cochlear implantation process with their life and own context. For clinicians, the core phenomenon is their strong sense of responsibility for children to get cochlear implants. The pre-condition to this phenomenon is their clear purpose and set of values relating to attainment of listening and talking for children with hearing loss. The context in which clinicians are working is a system with constraints and they don't always feel in control of their ability to do their job. Their ability to cope with the lack of control is related to the level of system or service support available. The alignment between parents and clinicians is related to the ability of parents to manage the work required for a child to have a cochlear implant and thus whether clinicians can deliver on their responsibility for a child to have a cochlear implant.
Discussion We discuss these findings in relation to the Burden of Treatment theory, and the relationship between the work generated by the implant assessment process and the capacity of parents to do the work. We propose that the Burden of Treatment theory has potential to explain much of the variation in time to cochlear implantation, and can be used to inform how services delivered.

287 - Tracking outcomes in pediatric cochlear implant users with exceptionalities
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The University of Texas at Dallas, Speech, Language, and Hearing, Dallas, United States [1]

Pediatric cochlear implant users with additional exceptionalities present challenges in diagnostic testing and therapeutic intervention for speech-language pathologists and audiologists. We expect children with cochlear implants who have additional exceptionalities to increase acquisition of communication skills after cochlear implantation. However, we expect them to do so at a slower rate, at a lower achievement level, and with greater variability compared to children without additional special needs who receive cochlear implants. This requires modification not only of clinical assessment protocols, but also of the definition of "success" after cochlear implantation For example, clinicians working with this population should place greater emphasis on objective measures (e.g., electrically evoked compound action potential, ECAP; electrically evoked stapedius reflex threshold, ESRT) to monitor device function and datalogging to track daily device use. In addition, "success" should focus on functional improvement after implantation (e.g., eye contact, independence, socialization), particularly for children with conditions which inhibit their ability to acquire verbal communication. Such functional improvement may be evaluated through formal and informal parental report as well as alternative methods of scoring of traditional measures (e.g., accepting signed and spoken responses). This session will review current research on communication and quality of life in this population, while also highlighting real-world clinical practices in assessing, treating, and defining success in these patients through a series of case studies.

506 - Cochlear Implants in Deaf and Deafened Adults: A Global Consultation on Lifelong Aftercare
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This paper presents the results of a new study, exploring experiences of adults after cochlear implantation. The purpose of the study is to investigate the issue of long-term support for deaf and deafened adults who have received cochlear implants (CIs). Although CIs have become routine provision over the past 30 years, information about ongoing follow-up over time has not been consistently collected in a robust manner. A recent international consultation of user groups highlighted this omission (Foundation Report, CIICA, www.ciicanet.org, 2021). This oversight in understanding is also evident in a recent publication Consensus Statements on Unilateral Cochlear Implantation in adults (Buchman et al., 2020). This paper does not include mention of the lifelong care that is required after implantation while making recommendations for medical, surgical and audiological care in the time around surgery (De Raeve, 2021). Additionally, the recent World Report on Hearing (2021) by the World Health Organization (WHO) stated that little is known about the barriers to the use of CIs, or the reasons for variation in access and benefits, and that cochlear implantation should not take place unless there was a rehabilitation infrastructure in place. The members of Cochlear Implant International Community of Action (CIICA), many of whom are CI users, have also prioritised this as an area of concern (https://ciicanet.org/).
Methodology The views of adult CI users will be obtained via a global online survey developed using Survey Monkey. The focus is on documenting what is currently in place in terms of rehabilitation and support post-implantation, and identifying areas of need. The survey includes both open and closed questions enabling both statistical analysis of the impact of variables such as global region, age at implantation, length of CI usage, and funding sources, and an examination of the open responses to explore perspectives and issues often not recognized by researchers (e.g., quality of rehabilitation, challenges in accessing services, suggestions for improvement etc.) The views of CI users on the impact of the pandemic on these long-term CI services will also be considered. The survey will be distributed to the CIICA community that includes 47 countries, 74 CI organisations, and 332 individual members (the majority of whom are CI users), and be made available in the five most common languages required by CIICA members (English, French, Spanish, German & Italian). The survey will also be made available via the CIICA website. Data will be analyzed by: age at implantation, length of time implanted, global region, bilateral implantation, funding sources, rehabilitation and technology support provided, and rehabilitation and technology support considered necessary over time. Responses to open questions will be further analyzed for themes that emerge related to supports and services in place, those that are lacking, and how these may be impacted by age and global area. The survey has been designed and piloted globally, and data will be collected over 2 months (January-February 2022) with analyses completed by April 2022 and findings ready for dissemination by May 2022. Results and Significance This study is the

first to collect global information from CI users themselves, on the long-term services required after implantation, to ensure that maximum possible benefit in adults is achieved in real life. The findings will contribute new and original information to the current knowledge of the impact of adult implantation, and form the basis for further work to maximise the long-term effectiveness of cochlear implantation. Gaining a better understanding of the supports currently in place for adult users of cochlear implants, and a better sense of their effectiveness, will reveal areas where additional support is needed. Developing this knowledge base is both timely and necessary given the growing numbers of adults receiving cochlear implants globally, especially as rates of seniors are growing. The impact of the pandemic on health services and funding, and the challenges faced, make it a priority to understand what is needed after implantation and how this is best provided to ensure maximum effectiveness of this intervention. Thisstudy will contribute to policy and health care reform, and offers a unique opportunity for CI users to make their voices heard in effecting change and improving services and supports.

EARLY IDENTIFICATION – NOVEL TECHNIQUES AND METHODS

451 - The ear as a central spot for vital sign monitoring: A remote usability study
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New wearable devices are offering new opportunities in diagnosis, health care and prevention. In the realm of the project MOND (Mobile, Smart Neurosensing System for the Detection and Documentation of Epileptic Seizures in Daily Life) a mobile, ear-worn sensor system for long-term recording of vital signs including ear EEG is under development. The aim is the automated detection of epileptic seizures in everyday life to diagnose the disease more specifically and to improve therapy. Currently different sensor prototypes and concepts exist, and it was unclear which sensor is the best from the user's perspective. It is essential that users are willing to wear the sensor technology continuously in daily life - even when sleeping.
The study goal was to identify the practicability in everyday life of the following two sensor prototypes: A wearable in-ear sensor (cosinuss° Two) and an adhesive ear-EEG system that included 10 electrodes placed around the ear (cEEGrid) connected to an EEG amplifier worn on the chest. In this study we investigated user experience and wearing comfort of the devices with focus on sleep and the influence of the in-ear sensor on hearing. Only non-functional EEG sensor prototypes were used.
The development of the "Remote Hearing Lab" allowed a no-touch evaluation in the home environment of the test person during the Covid-19 crises. A suitcase fitted with remote evaluation equipment was delivered to study participants. During the appointments it was possible to communicate with the test person via video call. To gain insights into user's needs and requirements a 24h-real-life testing was performed for both prototypes accompanied by a dairy, questionnaires and interviews about the experiences made in everyday life and the assessment of the sensors. In addition, several listening tests were conducted remotely to investigate the acoustic influence caused by the in-ear sensor. In total, 24 subjects (10 young normal-hearing, seven elderly slightly hearing impaired and seven patients with epilepsy) participated in the study.
The results showed that the following recommendations are important for the patients: long-term wearing comfort, non-stigmatising, flexible and easy handling, secure fit, and suitability for daily use - individual and independent of gender and age. Furthermore, it was shown that the in-ear sensor is convincing in everyday use due to its flexibility and non-stigmatization. But the in-ear sensor often led to pain when worn for longer periods (several hours) and especially during sleep when lying on the in-ear sensor side. For the test person with epilepsy, it is essential that there is no supplementary burden induced by wearing the sensor, especially when sleeping. The results of the listening tests showed that hearing ability was affected by the in-ear sensor, especially on speech intelligibility. However, listening effort also increased. Since the in-ear sensor is not completely closed, the effects are relatively small. With a completely closed coupling it could become more problematic.
The remote study design was successfully used to determine the design requirements and patient needs for everyday usage of mobile health devices with the aim to involve these demands and key insights in the further user-centered development process.
Key words: ear-connected sensors, usability, wearing comfort, user acceptance, wearables, health monitoring system, mobile health, remote study design
Funding code MOND: 2520DAT01A

51 - Toward the Development of a Test Battery for the Diagnosis
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Objectives and Materials: There is evidence that previous history of noise exposure, head trauma, and the aging process are associated with speech perception in noise difficulty even when there are no significant increases in the audiometric threshold at a conventional frequency range (250-8000 Hz). This condition (often referred to as "hidden hearing loss", or HHL) may also co-occur with other perceptual anomalies associated with noise damage and aging, such as hyperacusis and tinnitus. The current study is part of a larger project that aims to develop a test battery for the diagnosis of hidden hearing loss.
Method: To this end, forty-six ears of 23 participants (mean age 39.6 yrs, range = 18-59) with essentially normal hearing at conventional frequencies, who were mainly suffering from an understanding speech in noise, were recruited ("suspected HHL", or sHHL, group). The control group consisted of 228 ears (mean age 25.5 yrs, range =18-39) with normal hearing, no significant history of noise exposure as assessed by a standard questionnaire, no history of tinnitus, hyperacusis, speech intelligibility problems in quiet and noise, head trauma/concussion, or of recurrent middle ear infection. Although several behavioral and physiological measures were collected from all participants, this paper will focus on differences in auditory sensitivity measures between the sHHL and control groups. Hearing thresholds were measured in equivalent sound-pressure levels (RETSPLs) between 250-16000 Hz.
Results and Conclusions: Results indicated that the sHHL group had significantly higher thresholds at several extended high frequencies (9-16 kHz). In extended high-frequency thresholds were positively correlated with age for the sHHL, but not the control, group. No such correlation was observed at 8 kHz or lower frequencies. These findings show that extended high-frequency thresholds have the potential of providing clinically useful information for the assessment of hearing abilities in individuals with a history of noise exposure, head trauma, tinnitus or hyperacusis.

281 - A new way to assess infant hearing
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Humans and other vertebrates respond to unexpected events with a constellation of autonomic responses including pupil dilation. The novelty-elicited pupil dilation response (PDR) requires no voluntary participation, and can be assessed without anesthesia or the attachment of electrodes or other gauges. Our prior research in adults showed that the PDR is as sensitive as traditional methods of assessing hearing thresholds. We therefore investigated whether the PDR could serve as an indicator of frequency-dependent auditory detection in infants. A simple, no-contact hearing assay based on PDR was used to probe auditory detection in 43 children, ages 4 to 18 months old. We found that infants display a clear and robust sound-elicited dilation, the characteristics of which are uniform across individuals. Response magnitude is level-dependent, and can thus serve to measure hearing thresholds. Our data thus indicate that the PDR can be used to assess auditory detection, and thus infant hearing.

263 - Multiaxial localization audiometry
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The ability to locate the sound source develops from an early age. In past decades, when the examination of the infants hearing was performed by the observation of behaviors (Norther and Downs 2014), the changing ability of spatial localization was very important. Nowadays, listening skills in different spatial axes is crucial for various professions (e.g. firemen, policemen, military troops). In the same way it is important for people who use hearing aids or cochlear implants. People of any age with mild to moderate deficiency may have difficulty locating a speaker in a social event or in noisy environments (Gatehouse and Nobel 2004) or even to

locate the source of a ringtone or other alarm signals (important e.g. in older adults). Therefore, the ability of auditory localization and the diagnosis of which spatial axis there is more ease or difficulty may be useful for making decisions in therapeutics. In children there have been studies that have been more frequent in adults and have been generated indicators such as RMS (root square mean) error (Middlebrooks and Green 1991) or MMA (minimal audible angle) in children (Litovsky and MacMillan 1994). Maybe the lack of information and practice of hearing skills in space is debt to the fact of these assessments in general require a device with a lot of speakers in large rooms. In order to have a useful, cheap an more light tool for the evaluation of space skills, new software technologies that place sounds on different spatial axes through a conventional pair of headphones were used. A system was developed to test and represent auditory thresholds through audios commercially treated by mean as software referred to as 4D or 8D (ambisonic sound). This proposal and its possible applications in the field of audiological assessment are presented.
Key words: Spatial audiometry-ambisonic sound-audiometry software

MILD AND UNILATERAL HEARING LOSS (1)

473 - Hearing loss in the extended high frequencies in children:

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Hearing loss during childhood has deleterious consequences on all aspects of development, including speech-language communication. Hearing impairment in the extended high frequencies (EHFs; > 8 kHz) can occur despite clinically normal hearing. However, the consequences of reduced EHF hearing in children are not known. The objective of the present study was to examine the effects of reduced EHF hearing in children.
Participants with reduced EHF hearing were assigned into cases using a case-control design. Reduced EHF hearing was defined as hearing thresholds greater than 20 dB HL in at least one of the EHFs (10, 12.5, or 16 kHz). Audiometry and speech recognition thresholds (SRTs) using the digit triplets test were measured from 542 participants (4 - 19 years), and distortion product otoacoustic emissions were recorded in 48 children.
Thirty-eight children had reduced EHF hearing impairment regardless of a clinically normal audiogram. Hearing in the EHFs can decline as early as 9 years of age. Linear mixed-effects model, with adjustments for age effects, revealed that children with EHF hearing impairment had higher (poorer) mean SRT than the control group (effect size = small). The overall magnitude of distortion product otoacoustic emissions was lower for children with reduced EHF hearing (effect size = medium). In addition, the pure-tone average for standard audiometric frequencies was relatively higher (poorer) for EHF-impaired children.
Hearing impairment in the EHFs is common in children despite clinically normal hearing. EHF impairment is associated with poor speech-in-noise recognition and pre-clinical cochlear deficits in the lower frequencies where hearing thresholds are normal. This study highlights the clinical need to further investigate EHF hearing in children.

328 - Functional assessment of auditory attention in infants and young children withn unilateral hearing loss: Proposal for an evaluation methodology

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Unilateral hearing loss (UHL) is a common condition in which hearing is normal in one ear (pure tone air conduction threshold < 15dB HL) but there is hearing loss in the other ear (>25dB HL in two or more frequencies), according to the 2005 National Workshop on Mild and Unilateral Hearing Loss. UHL can range from mild to very severe and it can be of conductive, mixed or sensorineural type. UHL can occur in both adults and children. Approximately 1 out of every 1,000 children is born with UHL, and nearly 3% of school-age children have UHL. Prior to the implementation of Universal Newborn Hearing Screening (UNHS), UHL often went undetected until school-age unless specific predisposing conditions such as meningitis prompted earlier evaluation. The leading causes of UHL in children are congenital cytomegalovirus, inner ear malformation (enlarged vestibular aqueduct, cochlear aplasia…), bacterial or viral meningitis, GJB2 (Gap Junctions Protein

Beta2) mutations.Research findings about the general outcomes of children with UHL are controversial, although many studies have reported that school-age children with UHL experienced a variety of auditory, educational and psychosocial problems. The topic is still challenging and no common agreement has been reached within the scientific community regarding its treatment, with recommendations ranging from watchful waiting strategies to early interventions. Children with UHL usually experience additional issues while listening in noisy conditions, localizing sound and frequently do not develop age-appropriate cognitive skills.
The assessment of auditory attention and listening effort are crucial points in the management of these patients. The early identification of these difficulties is essential for the right therapeutic decision. The objective of this work is to stress the need for the definition of a new evaluation protocol, aiming to investigate the difficulties experienced by UHL patients in developmental age. The proposed evaluation set features methodologies with enhanced sensitivity, allowing to highlight problems that, either, would not be always recognizable using traditional audiological tests, which often display similar results to those expected in normal hearing people. With this intention, within the Audiology Unit (ENT Department) of Papa Giovanni XXIII Hospital in Bergamo, Italy, we have experimented a new evaluation protocol, involving 10 children, aged between 5 and 18 years, with a different degree of UHL. In our sample we did not include children with neurological, behavioral or cognitive disorders. The evaluation protocol includes traditional audiological diagnostic (pure tone audiometry, speech recognition audiometry, tympanometry with the study of acoustics reflexes, auditory brainstem response thresholds); MRI (Magnetic Resonance Imaging), for the morphological study of the ear structures; loudspeaker-based OLSA (Oldenburg Sentences Test), to study the speech recognition in a noisy environment (only for patients older than 8 years); Auditory Speech Sound Evaluation (A§E®), an extensive psycho-acoustic test suite with supraliminal auditory tests to assess the coding of intensity, spectral and temporal content of sound, while the patients were engaged in a double task analysis with minimal cognitive commitment; lastly, the VAUMeLF battery (Assessment of Auditory attention and Phonological Working Memory in the developmental age) was performed for testing auditory selective and divisive attention with standardized material.
From the analysis of the results it emerged that:
- the "wait and see" approach cannot be considered universally valid.
- the evaluation of listening in a noisy environment, the "listening effort" and auditory attention (especially when assessed in the dual task mode) is a priority in these patients. Listening-related fatigue is an understudied construct that may contribute to the auditory, educational and psychosocial problems experienced by children with UHL.
- in the evaluation of UHL it is necessary to go beyond traditional audiological tests, through the creation of a targeted protocol, specifically aiming to early detection of hearing attention difficulties and setting up a prompt and correct rehabilitation treatment.

Key words: Unilateral Hearing Loss, Hearing Attention, listening effort

156 - Early expressive vocabulary in children with mild hearing loss: a population sample of 2 year old children

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Background and aims Universal newborn hearing screening (UNHS) is successful in decreasing the age at detection of congenital hearing loss. This occurs across the spectrum of loss severity, with children born with mild loss also increasingly identified earlier than previously possible. Currently in Australia, around 50% of all hearing aid fittings in children under 12 months of age occur when the better hearing ear has no greater than a mild loss. This earlier fitting of amplification for mild losses is occurring without clear evidence of meaningful benefit to language outcomes. Evaluation of early language development could provide insight that will help guide such intervention decisions. Therefore, we aimed to (1) describe parent-reported expressive vocabulary development in children with mild bilateral hearing loss at age 2 years, and (2) compare these vocabulary skills to same age children born without hearing loss. Methods Data were collected on expressive vocabulary skills via questionnaires sent to families with children enrolled in the Victorian Childhood Hearing Impairment Longitudinal Databank (VicCHILD) around their child's second birthday. The Sure Start Language Measure (SSLM, mean 100, SD 15), a standardised parent-completed measure of early language development was used to collect information on expressive vocabulary skills. Child and family characteristics, including details of amplification use, were obtained from VicCHILD. Linear regression adjusting for potential confounding factors was used throughout. Comparisons were made between different subgroups within the hearing loss cohort, and to a population without hearing loss of the same age. Results Data were collected over the period from July 2015 to September 2021. Responses were received from the parents or caregivers of 57 children

(24 female (42%)) who had a diagnosis of mild hearing loss in the better ear at enrolment into VicCHILD. The mean socio-economic indexes for areas (SEIFA) score (a measure of social disadvantage) indicated less disadvantage for responders compared to non-responders. Mean age at expressive vocabulary assessment was 25.6 months (SD 1.8 months). Twenty-five children (43.9% of the sample) were reported to have been fitted with hearing aids (mean age at fitting 8.4 months, SD 5.6 months), 11 children were unaided (19.3%); aided status was unknown for 21 children (36.8%). Mean SSLM score for the entire group of children was 89.7 (SD 16.8); SSLM score for children fitted with amplification was 89.5 (SD 15.2), those unfitted 91.0 (SD 21). Females showed lower SSLM scores than males (84.4 vs 93.5).These scores overall represent poorer expressive vocabulary scores than observed for same age children without hearing loss. Further exploration of the effect of potential confounders, patterns of amplification use and comparison to children without hearing loss will be presented. Conclusions Initial analyses of a population-based sample suggest children with bilateral mild hearing loss at age two years are underperforming in their expressive vocabulary compared to age-expected norms. As data collection and analyses progress, elements impacting on performance early in life may be flagged, presenting an opportunity to address these factors before they compound across childhood.

Keywords: mild hearing loss, expressive language, vocabulary, universal newborn hearing screening, paediatric

316 - Neural Processing and Perception of Speech in Children with Mild to Moderate Sensorineural Hearing Loss

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Mild (21-40 dB HL) or moderate (41-70 dB HL) sensorineural hearing loss (MMHL) can lead to persistent changes to the cortical processing of speech sounds. This was evidenced in a study conducted on 46, 8- to 16-year old children with MMHL and 44 normally-hearing (NH) age-matched controls. While present in younger children with MMHL, there was no significant MMN in older children with MMHL. However, to date no studies have examined speech processing at the subcortical level in children with MMHL, yet this is known to be linked to speech perception in noise (SIN) in NH children. Moreover, the effects of amplification on the neural encoding of speech remain poorly understood, with previous data suggesting a benefit at the subcortical but not the cortical level.

Here, we aimed to investigate (1) the subcortical and cortical processing of speech sounds in children with MMHL, (2) the relation with SIN, and (3) the effects of amplification on the neural processing of speech, for children with MMHL. Behavioural thresholds were measured at 70 dB SPL for consonant identification in both steady and fluctuating noise. Subcortical and cortical EEG activity evoked by speech stimuli were simultaneously recorded in 18, 8- to 16-year old children with MMHL and 15 age-matched NH controls. The frequency-following-response (FFR) and MMN were used as indices of speech processing at the subcortical and cortical levels, respectively. For the MMHL group, stimuli were presented both unamplified (70 dB SPL), and with a frequency-specific gain (without compression) based on their individual audiograms.

Behavioural thresholds were poorer for children with MMHL than NH controls, whatever the background noise. At the subcortical level, children with MMHL showed a smaller FFR than NH controls' in the unamplified condition. With simulated amplification, the FFR of the MMHL group was comparable to that of NH controls. However, the relationship between subcortical encoding of speech and SIN was not significant. At the cortical level, there was no significant MMN in children with MMHL presented with either unamplified or amplified speech. The neural processing of unamplified speech may be impaired at both subcortical and cortical levels in children with MMHL. Moreover, amplification may benefit auditory processing at subcortical but not cortical levels in this group. We offer two alternative explanations for our findings: increasing multi-sensory integration at successive levels of the auditory system, and/or later maturation of the auditory cortex compared to the inferior colliculus.

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3 - Progression and Risk Factor Analysis in Pediatric Unilateral Sensorineural Hearing Loss

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Objective: To elucidate common risk factors of unilateral pediatric hearing loss, and explore the prevalence of disease progression.
Methods: A retrospective study was performed to investigate pediatric patients seen at a tertiary pediatric otolaryngology clinic for unilateral sensorineural hearing loss (UHL) over a ten-year period. Through clinical chart and audiogram review, patients with UHL were grouped by severity. Radiographic imaging results were also reviewed.
Results: 81 patients were identified with UHL. 51 (63%) were determined to have severe to profound hearing loss (S-UHL), and 30 (37%) had mild to moderate hearing loss (M-UHL). Identifiable risk factors were determined in thirteen and ten patients, respectively. Prematurity was the most common risk factor identified, followed by a NICU stay. CT Temporal Bone or MRI radiographic results were available for 37 patients with S-UHL, and 33 patients with M-UHL. An identifiable cause was seen in 22% of cases. Enlarged vestibular aqueducts were the most commonly identified radiographic pathology, followed by cystic cochlea. Patients were also evaluated for progression of severity, or progression from unilateral to bilateral hearing loss. 5.9% of patients with S-UHL progressed to bilateral hearing loss. Progression of severity and progression to becoming bilateral was seen in 23.5% of patients originally diagnosed with M-UHL.
Conclusion: Pediatric unilateral sensorineural hearing loss can be attributed to many factors. Risk factors can be identified in about 30% of cases, and imaging can identify about 20% of cases. Follow-up is essential as progression was observed in both severity and bilateral involvement.

437 - Mild Matters: Randomised controlled trial of amplification for infants with bilateral mild hearing loss

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Background: With early detection of mild hearing loss, pre-lingual infants/children with mild hearing loss are increasingly being fitted with hearing devices, despite limited evidence of benefit. Aims**:** This proof-of-concept randomised controlled trial (RCT) of early hearing device fitting versus no fitting aimed to 1) gather preliminary data, primarily on language, and secondarily on social abilities, functional performance and listening effort, at 6 months post-randomisation and 2) determine the RCT's acceptability and feasibility in children <2 years old with bilateral mild hearing loss. Methods: Participants were recruited from three states in Australia. Children could be enrolled if they met all of the following criteria: a) born in any of the three states and was Australian resident/citizen, b) less than 2 years old, c) had parents/carers who spoke English adequately to give consent, d) had, within the last 3 months, confirmed bilateral mild hearing loss (21 to 40dB HL) across at least 3 frequencies over the range of 250 to 4000 Hz by objective or behavioural testing, and e) had pure sensorineural hearing loss. Enrolled children were randomized to either intervention (hearing devices) or control (no hearing device) groups, with allocation concealment. Primary outcome (language) was measured by the Communication and Symbolic Behavior Scales Developmental Profile Infant-Toddler Checklist (CSBS) Speech Composite. Secondary outcomes were measured by the CSBS Social Composite (social skills), Parents' Evaluation of Aural/oral functional performance of Children (PEACH-plus, functional performance/listening effort), Parenting Morale Index (psychological well-being), Family Adjustment to Childhood Developmental Disability (parent-child relationship) and Assessment of Quality of Life (AQoL-4D, quality of life). Feasibility was measured by the proportions of children enrolled / dropped out / changed treatment group and device use. Acceptability was measured by parent report. We subsequently conducted interviews with i) diagnostic and rehabilitation audiologists and ii) parents/caregivers of infants with mild hearing loss to explore barriers and enablers to RCT participation. Results: Of 40 potentially eligible families, nine (23%) declined, three were not contactable (7%), and 26 (65%) were ineligible. Of these, nine (35%) did not meet hearing threshold inclusion criteria (i.e. three frequency average was mild, but hearing threshold at one or more frequenciesolds were <21dB or >40dB), 11 (42%) were already fitted or had made a decision on fitting hearing devices, two (8%) had conductive hearing loss, and the remaining four (16%) had other issues

that prevented them from meeting inclusion criteria. Two of 11 (18%) eligible families participated. With the limited sample size, outcome measures were not compared between groups. Neither participant dropped out nor changed group post-enrolment. The intervention participant reported device use for 21-47% of waking hours, data logging indicated average use of 4.5 hours/day. Both participants expressed taking part in the RCT to be acceptable. We conducted 11 interviews with parents/caregivers and 10 interviews with audiologists, which revealed major barriers to participation. For parents, the main themes were: the timing of the study (parent stage in journey post-diagnosis, information and uncertainty, decision about hearing aids and management options), the study design (removal of choice and parent preferences, need for good communication and clarity about the study) and their attitudes towards research. For audiologists, the key themes were: audiologists as recruiters (perceptions of parent factors, appointment constraints, taking the lead from family, management bias, communication between audiologists and families), study design (duration, randomization, study criteria) and audiologists' perspectives on participation and research. **Conclusions:** We were unable to recruit sufficient numbers of children for our proof-of-concept RCT. Many factors contributed to the low recruitment numbers, in particular: inability to meet hearing threshold criteria and parental preference to make decisions on hearing aid fitting. If setting up for future trials, a more pragmatic approach may need to be taken to allow for including hearing thresholds in the moderate hearing loss range. Better engagement of audiologists as recruiters, and additional supports for parents, may also be necessary. However, alternative methodological approaches without randomisation may ultimately be required to determine whether early hearing amplification benefit infants with mild bilateral hearing loss.
Keywords: pediatric hearing loss, hearing aids, rehabilitation, newborn hearing screening, early intervention, language development, psycho-social development

116 - Language and auditory development of children with single-sided deafness and a cochlear implant
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Each year, approximately 20 children are born in Flanders (Belgium) with single-sided deafness (SSD), i.e. profound hearing loss in one ear (> 90 dB HL) and normal hearing in the other ear. These children have no access to binaural hearing, and as a result, their abilities to localize sounds and understand speech in noisy environments are impaired. Unfortunately, SSD can hamper children's development beyond just auditory skills. A growing body of research suggests that unilateral hearing loss is a risk factor for speech-language delays. Moreover, if left untreated, the single-sided auditory deprivation affects the brain development of these children. This results in asymmetric auditory processing, with increasing bias in favor of the normal hearing ear, as well as disruption of higher-order connections in the brain.
Although these findings highlight the need for intervention, there is currently no standard care for children with SSD in Belgium (as is the case for many other countries worldwide). The most promising treatment option is a cochlear implant (CI) in the deaf ear, as it offers the potential to restore binaural hearing. For children with congenital SSD, early implantation is likely of key importance, given the sensitive period for brain development early in life. In the multicenter CICADE study (a collaboration between UZ Leuven, UZ Ghent, UZ Antwerp, and GZA) sixteen infants with congenital SSD received a CI at a very young age (range 8-26 months, mean 14.0 ± 4.9 months). At regular intervals we document the development of these children in terms of receptive and expressive language skills, cognitive abilities, and (from the age of four) balance, localization and speech perception skills. Additional measures include assessments of the children's language environment with the LENA system, as well as parent questionnaires addressing their auditory, language, and socio-emotional development. This wide range of outcome measures will provide a holistic view on the treatment potential of a CI for children with SSD.
At the HEAL conference, we will present data on the language and auditory development of the implanted children, starting 2 months pre-implantation and ranging to up to 5 years post-implantation. We will compare their data to those of both normal hearing peers and single-sided deaf children without a CI.

MILD AND UNILATERAL HEARING LOSS

95 - Improving clinical management for children with mild hearing loss through audibility-based hearing aid fitting criteria

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Introduction: With the advent of early hearing detection and intervention programs, developmental outcomes in children with hearing loss have improved in recent years. However, the benefits of these advances for children with mild bilateral hearing loss (MBHL) have not been fully realized, due in part to clinical ambiguity about the benefits of intervention for this subgroup of children with hearing loss. Even after hearing loss has been confirmed, some children with MBHL do not receive intervention due to uncertainty among audiologists, speech-language pathologists, and parents about the potential benefits of early intervention and amplification. Furthermore, children with MBHL who are fitted with amplification often do not use their devices consistently, leading to persistent developmental delays.
Methods: We examined whether children with MBHL exhibit delays in language and reading skills in elementary grades. We also explored the use of an audibility-based hearing-aid candidacy criteria for children with MBHL. Participants included 60 children with MBHL and an age-matched group of 69 children with typical hearing. Children were tested on a battery of audiologic, language, and reading measures. For children with MBHL, the unaided and aided speech intelligibility indices (SII) were calculated for both ears using simulated real-ear measures with measured real-ear-to-coupler difference. Parents completed questionnaires regarding amount of daily hearing aid use. Unaided and aided SII and amount of daily hearing aid use were combined together into a metric called hearing aid dosage.
Results: Children with MBHL demonstrated significant delays in morphological awareness and language comprehension. Reading and vocabulary skills were commensurate with typical hearing peers. Consistent use of well-fit hearing aids benefitted children with unaided speech intelligibility indices of less than 80%.
Discussion: The knowledge and clinical tools discussed in this talk will enhance our ability to make evidence-based decisions about intervention for children with MBHL and improve developmental outcomes for these children.

449 - AUDIOLISTIC: Language and environmental analysis in early intervention groups for children with mild hearing loss

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Although hearing aids (HAs) are a useful tool to increase the access to auditory input for children with hearing loss, these children still encounter challenges while growing up in a sound-dominated society. In the Netherlands, each year around 90 children are born wit a permanent moderate hearing loss (MHL). Up to now, we do not have a complete picture of the acoustic environments and linguistic input for this specific group of children, as most research is focused on children with severe and profound HL, often using cochlear implants. As a result, the knowlege on the potential challenges and potential solutions to these challenges remain limited for this group of children with MHL.
Mainly the first years of a child's life are crucial for language development. In the Netherlands family centered early intervention (FCEI) groups focus on speech and language development for these young children. It still remains unknown if the environment of the FCEI groups is optimized for these children to learn language optimally. Insight in the conditions at the FCEI groups can contribute to optimize the environment of children with MHL to learn language.
Aim: The project aims to provide a comprehensive insight in the acoustic and linguistic environment of the Dutch FCEI groups, which is an important place for language development for children with a MHL. The outcomes of this project will lead to clinical and practical tools for FCEI programs for children with MHL.
Method: A total of 15 young children within the sensitive language learning period (0-4 years) with MHL using HAs will be included in this study. Data collection will be performed during one FCEI group day. HAs have an audio scene analysis, meaning that they extract information about the environment to classify the scene. For example, the HA can analyse the amount of time a HA user is in a silent or noise situation. Data from the scene analysis of the childrens' HAs will be extracted to obtain information about the auditory environment.
A Language Environment Analysis (LENA) recorder will be worn by the child to classify the linguistic and auditory environment during the FCEI group. Furthermore, in terms of acoustics the speech transmission index (STI) and reverberation time will be measured to obtain insight into the auditory environment.

Preliminary results: We will discuss important outcomes of the measurements such as the amount of linguistic input directed to the child, conversational turns between caregiver and child, the acoustic environment in which the child resides and the use of hearing technology.
Keywords: FCEI (family centered early intervention), hearing technology, acoustic characteristics, linguistic input, LENA (Language Environment Analysis)

361 - Rehabilitation of children with congenital unilateral conductive hearing loss
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Rationale: Potentially, binaural hearing abilities in children with non-operable congenital unilateral conductive hearing (UCHL) loss can be achieved with different amplification options. Amplification options comprise (semi)implantable devices, directly stimulating the inner ear at the impaired side. These devices improve audibility, especially for sound originating from the hearing impaired side. However, whether the new bilateral input does result in accurate processing of binaural cues remains unclear. Limited benefit and even non-use after fitting has been reported. The implanted ear has to compete with the well-developed normal hearing ear. The child has to learn to use the new digital processed and delayed input and fuse it with that of the normal ear. From a technological point of view, the available amplification options are remarkable but also have limitations in gain and output. This results in an asymmetry in hearing even after intervention, which might disrupt binaural processing. Stimulation of the contralateral cochlea by means of transcranial bone-stimulation might affect binaural processing as well.
Objectives: An important and unresolved remaining question regarding treatment of UCHL is whether early implantation would increase the chance in restoration of binaural processing. However, in UCHL the impaired ear is not fully deprived and stimulated through children's own voice and loud sounds.
Methods: Participants underwent localization testing in unilateral and bilateral hearing conditions (unaided / aided). Broadband noise bursts (BB; 0.5-20 kHz), high-pass noise bursts (HP; 3-20 kHz), and low-pass noise bursts (LP; 0.5-1.5 kHz) were randomly presented at three different sound levels (45, 55, and 65 dB, A-weighted (dBA)). All stimuli had 150-ms duration and were presented in pseudo-random.
Results: We demonstrate that early implantation with a bone-conduction implant or a middle ear implant does not result in better sound localization abilities compared to children implanted later in life.
Conclusions: Considering the reported limitations parents can chose to wait until their child has reached an age at which he/she can make the decision concerning invasive treatment him/herself. Still, this is a difficult call to make since unilateral hearing comes with clear limitations in daily life, and reorganization of the auditory system in developmental monaural hearing loss is not fully understood.

491 - A longitudinal study of the expressive vocabulary in children with moderate hearing loss - the impact of auditory variables and early consonant production
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The universal newborn hearing screening followed by early intervention has led to an increased number of children with hearing loss reaching speech and language outcomes on par with typically hearing peers. However, research has found that expressive vocabulary is one of the language domains in which children with hearing loss score lower compared to their typically hearing peers. In this study, the early expressive vocabulary development was investigated in a group of children with moderate hearing loss (HL). Size and development of expressive vocabulary from 18-36 months were analyzed and compared to a group of children with typical hearing (TH). For the children with HL, the impact of auditory variables on number of words were examined. The relationship of early consonant production to number of words produced of both groups were examined and the phonological complexity of reported words was compared between the groups. Results showed that the children with HL produced a similar number of words as the TH at 18 months, but fewer at 24

and 30 months. Hours of HA use was the main factor showing significant correlations to number of words. The number of different true consonants at 18 months for the whole group showed a significant relationship to number of words produced at 24 months. No significant differences were found between children with HL and children with TH regarding phonological complexity of reported words. Meanwhile the study was controlling for factors identified in research to influence these outcomes, elaboration to possible other factors affecting vocabulary outcomes for this specific group of participants will be discussed.
As the findings indicated that the children with moderate HL showed a slower progress in their expressive development with age, the participants were invited for a follow-up study at six years of age. Children were tested on expressive vocabulary, phonology, tests of hearing in noise, datalogging of hearing aid use and use of assistive hearing technology in preschool. Parents filled out questionnaires on functional auditory performance in everyday life as well as their child´s level of phonological awareness. Data collection of the follow-up study has just ended, making new results ready to present in June 2022.
Keywords: longitudinal, vocabulary, hearing aid use

NOISE EXPOSURE

496 - Motivational Interviewing as an Approach to Reducing the Negative Health Effects of Noise Exposure

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Background. Despite its many limitations, use of hearing protection devices remains the primary method of protecting workers from auditory and non-auditory effects of noise exposure (e.g., noise-induced hearing loss, cardiovascular disease). Traditional educational approaches have had limited effectiveness in helping users to achieve the high rate of use necessary to be effective, exposing to the need for more effective strategies. Although motivational interviewing has been effective in changing a variety of health-related bahaviors (e.g, diet, medication use), its use in noise control has not been tested. The purpose of this study was to develop and test the feasibility, acceptability, and preliminary effectiveness of a motivational interviewing intervention aimed at reducing noise exposure among agricultural producers.
Methods. In a one-group pre/posttest design, we provided a series of 2-3 short telephone-based motivational interviewing sessions for agricultural producers. Measures of noise exposure, use of hearing protection devices, and related attitudes and beliefs were collected by survey items at pretest and several weeks after the intervention. The intervention used motivational interviewing principles and strategies delivered by specially trained health coaches. Data were analyzed using descriptive methods.
Findings. Regarding feasibility, the telephone-based intervention was practical for delivery to the geographically dispersed, hard-to-reach worker group, even in the context of the COVID pandemic, although recruitment was protracted. Participant ratings of intervention acceptability were very high, with participants rating the program as >6 (out of 7) in 14 of 15 measures (e.g., length, frequency, phone-based, timing, number of sessions, quality of coach, new ideas, interesting, helpful. (“I found the program to be designed for me personally” was rated somewhat lower, at 5.83). (Effectiveness results are pending, and expected to be available by the time of the June conference.)
Conclusions/Implications for Practice. Motivational interviewing is a feasible and acceptable intervention among agricultural producers, and may offer a more effective approach to increasing use of hearing protection devices among noise-exposed workers. Results of the study will inform development of a larger-scale effectiveness test of this new approach designed to prevent noise-induced hearing loss, cardiovascular disease, and other negative health effects associated with high noise exposure. Ultimately, this work is expected to improve the hearing health and quality of life among noise-exposed workers, particluarly agricultural producers as a high-risk, hard-to-reach, and underserved group.
Key words: prevention, intervention

368 - Personal music players use and other noise hazards among children 11 to 12 years of age

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Background Exposure to loud music—due to widespread personal music players (PMPs) and noisy leisure activities - are major risk factors for noise induced hearing loss (NIHL) in adolescents. However, there is little evidence of the impact of noise on the hearing of younger children. This study aimed to explore an association between PMP use and hearing, and to identify other sources of noise among children.
Material and Methods The study sample consisted of 1032 children aged 11–12 years old. Personal Music Players use and other noise exposures were evaluated using a survey. All children underwent tone audiometry hearing examination in frequencies 0.5, 1, 2, 4 and 8 kHz. Tests were performed using the screening device – Sense Examination Platform. Hearing loss was defined as air threshold values of 25dB HL or greater for any frequency at least one ear.
Results We found that 82% of the children had a PMP, and 78% were exposed to noise when playing computer games. An audiometric notch was documented in 1.3% of the children. Only 11.5% of the children ever used hearing protection while engaged in noisy activities.
Conclusion We found no convincing evidence of an association between PMP use and hearing thresholds, although our results suggest that tinnitus may be an early sign of NIHL in young children. The study shows a need to provide children, their parents, and educators with knowledge of how to take care of hearing, including how to avoid and minimize noise exposure.

503 - Comparison of temporary changes in hearing threshold levels and otoacoustic emission levels after short term exposure to dance music

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The “make listening safe” campaign from the WHO was launched in 2015 and is focused on reducing – preventable- NIHL caused by recreational exposure to loud sounds (https://www.who.int/activities/making-listening-safe). It is aimed at raising awareness on the risks of NIHL and on safe listening practices for (young) individuals. In this study one of the advices given in this campaign, take a break during the music, is examined in young subjects.
Objective: Comparison of temporary changes in hearing thresholds and otoacoustic emission (OAEs) after dance music exposure with and without a break during the exposure.
Design: Changes in pure-tone-audiometry (PTA) and OAEs at pre-determined time points were compared in a cross-over design consisting of two hours of music, either consecutively or with a break. Both distortion product and transient evoked optoacoustic emissions (DPOAE and TEOAE) were measured, audiometry was measured in 1-dB stepsize. Test-retest measurements were used to define when an individual change could be considered to be significant.
Sample**:** 18 Normal hearing subjects.
Results**:** Changes in pure-tone threshold were observed in both conditions and were similar, regardless of the break. Temporary threshold shifts (TTS) could be averaged for 1, 2, and 4 kHz. The shift immediately after ending of the music was 1.7 dB for right ears, and 3.4 dB for left ears. The difference between left and right ears was significant. One hour after the exposure, right ears were recovered to baseline conditions whereas left ears showed a small but clinically irrelevant remaining shift of approximately 1 dB. Comparison between PTA, TEOAE and DPOAE showed that changes from baseline were on average 2.50 dB for PTA, 0.61 dB for TEOAE and 1.04 dB for DPOAE. These changes were similar for the condition with and without a break during the exposure, and exhibited a similar time-pattern. PTA and OAE returned to near baseline condition within one hour after exposure.
There was no relationship between individual changes in PTA and TEOAE, a very limited relationship between changes in PTA and DPOAE. The overall number of significant individual shifts was low and shifts did not reproduce. There was no clear advantage of one type of measurement over another.
Conclusions**:** The advice to use chill-out zones is still valid, because this helps to reduce the duration to the exposure. This study does not provide evidence that a rest period gives an additional reduction of temporary threshold shifts. PTA, TEOAE and DPOAE exhibited a similar pattern in time after noise exposure. Overall

effects were small. The data shows that the sensitivity of audiometry measured in 1 dB step size is comparable to OAEs in detecting significant individual shifts. There is a lack of reproducibility in all three methods and a lack of agreement *between* the methods. The data does not support an increased sensitivity of OAEs.
Keywords: OAE, TEOAE, DPOAE, hearing damage, noise-induced hearing loss, temporary threshold shift

USE AND DEVELOPMENT OF OTOEMISSIONS

448 - A Manifestation of Scaling Symmetry in the Fine Structure of Transient Evoked Otoacoustic Emissions

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Objectives. In accordance with idea of scaling symmetry of cochlea we can expect that at least some components of the transient evoked otoacoustic emission (TEOAE) should be similar in shape but with duration almost proportional to latency. The simple filtering in frequency domain can't reliably recover the shape of these components because they can overlap each other. In our previous work we proposed and tested the method based on blind deconvolution with L1 regularization in exponential time scale. It was found that the relevant components existed, but constituted only a part of signal, and the remaining activity disturbed the convergence of the algorithm. To separate these kinds of signals a pitch-envelope analysis (PEA) was developed.
Materials and methods. TEOAE data obtained in response to click stimulation were collected from 10 normally hearing volunteers using ILO probes, professional sound card and preamplifiers of custom design. The data in gaps between click series were processed using spectral analysis, and components of long duration like spontaneous otoacoustic emissions were removed. Then the responses were averaged off-line using weighted averaging in time and frequency cells. On the next stage the result of averaging was split using PEA and the components far from scaling symmetry were removed. Although this operation can be performed using time-frequency filtering PEA gives better result because not relevant components can be traced back to the region of interest. On the last stage after the correction of delays by phase filtering the blind deconvolution with L1 regularization in exponential time scale was applied. For calculation of the exact relationship between time scale and latency of components the appropriate optimization of phase filter was applied. All algorithms were carefully optimized and tested on a large set of modeled data and on a data obtained without stimulation.
Results. It was approved that the algorithm didn't produce false components, but the modeled components of different shapes were detected without disturbance. For all records the algorithm produces an elementary response like a tone burst with almost constant amplitude, sharp cut-off and a splash on first periods. It was shown that at least a part of TEOAE signal can be expressed as a sum of elementary responses which parameters almost correspond to the hypothesis of scaling symmetry.
Conclusion. This chain of methods can estimate both the deviation from scaling symmetry and the shape of the elementary response which is important for understanding the micromechanics of cochlea. The calculated shape can be interpreted as an activity of a single outer hair cell and is in accordance with the published results of 3D simulations and direct measurements in animals.
Keywords: Transient evoked otoacoustic emissions, outer hair cell, cochlea

488 - Evaluation of Medial Olivocochlear System Function in Individuals with Vitamin B12 Deficiency

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Introduction: Vitamin B12 deficiency can affect the hematological, gastrointestinal, and neurological systems in humans. Neurological damage caused by vitamin B12 deficiency results from pathological changes resulting in demyelination, axonal degeneration, and neuronal death. In some studies, it has been shown that vitamin B12 deficiency causes tinnitus, hearing loss, and noise-induced hearing loss. These associations reported that there may be a relationship between vitamin B12 deficiency and dysfunction of the auditory pathway. The olivocochlear efferent system is the system that plays a role in the modulation of the auditory system and

protects the auditory system against high-intensity auditory stimuli. The best method to show the Medial Olivery Complex (MOC) effect is to reveal the MOC activity by giving an audible stimulus to the opposite ear during the otoacoustic emission measurement. The aim of this study is to evaluate the medial olivocochlear efferent function in individuals with vitamin B12 deficiency in the presence of contralateral noise with the transient evoked otoacoustic emission test.
Method: 15 individuals with normal hearing (14 F, 1 M) with low B12 value (<250 pg/mL) and 20 individuals with normal hearing with normal B12 value (>250 pg/mL) (15 F, 5 M) are included. Pure tone audiometry, tympanometry, acoustic reflex, TEOAE, and TEOAE test in the presence of contralateral stimuli were performed on all participants. Echoport ILO292 USB II (Otodynamics, Hatfield, UK) was used for emission measurement. The measurement was obtained by masking 65 dB SPL click stimuli with contralateral 50 dB SPL broadband noise. Both masked and unmasked emissions were recorded. In the presence of suppression, a 0.5 dB decrease in TEOAE values was accepted as suppression. SPSS Version 22 was used for statistical analysis and a p-value of <0.05 was considered statistically significant.
Results: There was no statistically significant difference between the pure tone thresholds of the two groups. There was a difference in the TEOAE signal-to-noise ratio between the two groups at all frequencies, but the difference was not statistically significant. The difference between suppressed TEOAE signal-to-noise values was not statistically significant. When the average amount of suppression was compared, the mean of suppression was higher at 1 and 1.4 kHz in the right ear in the group with a high B12 value, and at all frequencies in the left ear compared to the group with a low B12 value. However, this difference was not statistically significant. It was observed that suppression occurred in more people in the group with a high B12 value than in the group with a low B12 value at every frequency except 4 kHz.
Conclusion: The fact that more people in the group with high B12 levels had significant suppression made us think that a more detailed study should be done on this issue. The study showed that the B12 level can be effective on the efferent system. The fact that the difference between the amount of suppression was not statistically significant suggested that larger groups should be studied and that the study could be expanded by determining a cut-off value worse than 250 pg/mL clinically.
Keywords: Vitamin B12, efferent system, medial olivocochlear system

495 - The efferent auditory system in young people exposed to auditory factor risks
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Introduction: The efferent auditory system is a complex system. The medial olivocochlear efferent system is responsible for sound localization, auditory attention, auditory sensitivity and detection of the acoustic signal in the presence of noise. Otoacoustic emissions (OAE) allow us to assess the motor activity of the outer hair cells and are extremely sensitive to cochlear damage, namely that caused by the frequency of parties where young people are exposed to loud music, smoking and alcohol. Several studies indicate that suppression of OAE is the only test that can contribute to the assessment of the efferent system.
Objective: The aim of this study is to verify if the efferent system function is maintained after going to a party and being exposed to loud music, smoking and alcohol.
Methodology: Transient suppression OAE with contralateral noise were performed at frequencies of 1, 1.4, 2.0, 2.8 and 4 kHz to 13 normal hearing young people before and after attending a party. The equipment used was the Otodynamics ILO292 USB-II. Written informed consent was obtained prior to initiating the study.
Results: The amplitude of transient OAE decreased after the party, but there were no statistically significant differences. Regarding the suppression effect, before the party, it was found in all frequencies studied both in the right ear (1.4-0.3) and in the left ear (0.62 to 0.18). After the party, there was a slight decrease in the suppression effect, remaining present and not showing statistically significant differences.
Conclusion: This study seems to indicate that the medial olivocochlear efferent system maintains its function even when exposed to risk factors for cochlear damage such as loud music.
This work is co-financed by the European Regional Development Fund (ERDF), through the partnership agreement Portugal2020 - Regional Operation Program CENTRO2020, under the project CENTRO-01-0247-FEDER-047083 A4A: Audiology for All.
Keywords: Supression OAE; young; noise exposure; efferent auditory system

498 - Genetic and electrophysiological testing of children with auditory neuropathy spectrum disorder

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Objective: Auditory neuropathy spectrum disorder (ANSD) is an electrophysiological label, that incorporates patients with hearing loss of different etiologies and pathogenesis, but united based on the presence of pre-neural cochlear responses such as otoacoustic emission (OAE) and cochlear microphonics (CM) and absent or grossly abnormal neural responses – auditory brain steam responses (ABRs) are usually absent. The ANSD etiology and pathophysiology predispose clinical features and cochlear implantation outcomes: patients with auditory synaptopathy have much better rehabilitation outcomes than patients with auditory neuropathy type of ANSD.
The aim of this study was to explore genetic basis of ANSD in our group of patients and estimate electrophysiological features of hearing loss in children with ANSD of different etiology.
Methods: 46 children with ANSD underwent two-step genetic testing: first step – *GJB2* gene testing to exclude *GJB2*-related hearing loss; second step – Next Generation Sequencing (NGS) to explore another 30 hearing loss genes (including *OTOF* gene). 12 children after NGS-based testing underwent exome sequencing. Electrophysiological testing in this study, besides standard audiological tests, included registration of electrically evoked auditory brainstem response (eABR) and intracochlear electrocochleography (ECoG), which were performed after cochlear implantation in 18 and 22 ANSD cases respectively. eABRs were recorded via Eclipse EP25 Interacoustics with eABR External Trigger protocol. Electrical monopolar or bipolar stimulation was achieved with Custom Sound EP software. At least 3 electrodes were tested in each patient. The ECoG was performed using Active Insertion Monitoring systems for Advanced Bionics users and Cochlear Research Platform - for Cochlear users.
Results: NGS-testing revealed OTOF-related ANSD in 10 out of 46 tested cases. All 10 children with the OTOF-related ANSD passed hearing screening. OAE were present till the last testing at the age of 12 years in the oldest child. ABR were not detectable at 100 dB nHL, ASSR were measurable bilaterally at all frequencies in all cases, but they did not correlate with behavioral thresholds. After cochlear implantation auditory nerve action potentials to electric stimulation were detected within normal range, and eABRs were recordable in all tested OTOF cases. Clear CMs were obtained at all tested frequencies during intracochlear ECoG.
NGS and exome sequencing also revealed cases of ANSD due to mutation in MYH14, MYO15, TWNK.
EABR were recordable to stimulation with basic parameters (pulse width, stimulation rate) at all tested electrodes in 13 patients (5 OTOF-related ANSD, all 5 prematurity cases and 3 ANSD cases of unknown etiology). In 5 patients (1 hypoplastic cochlear nerve, 4 ANSD cases of unknown etiology) eABRs were absent or recordable only at some electrodes with specific stimulation parameters. These data were well correlated with the type of ANSD and poor outcomes of cochlear implantation in these 5 cases.
Intracochlear ECoG revealed several trends in patients with ANSD: CMs were recordable in all patients with ANSD at most tested frequencies, including high frequency stimuli; CM thresholds did not correspond with behavioral thresholds, they were much lower than pure tone audiometric thresholds; summating potential, compound action potentials and auditory nerve neurophonics were recordable in several patients. The lowest responses were obtained in prematurity cases. Difference in EcoG results might reflect differences in pathophysiological mechanisms of ANSD, but these results require further investigation.
Summary: Genetic (especially for OTOF gene mutations) and electrophysiological testing (especially eABR) might reveal etiological and pathophysiological mechanism and predict rehabilitation outcomes in children with ANSD.
Keywords: auditory neuropathy spectrum disorder, OTOF, eABR, electrocochleography

TINNITUS

261 - A study on risk factors for tinnitus incidence and impact of newly developed tinnitus: results of the Netherlands Longitudinal Study on Hearing

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Introduction Tinnitus affects millions of people worldwide. It is associated with a decreased quality of life, distress and depression. Reports about prevalence of tinnitus vary between 5 and 43%. Though tinnitus is highly prevalent, only limited information exists on risk factors for developing tinnitus. In a majority of patients, tinnitus is associated with hearing loss, but uncertainty exists about other risk factors. Little is also known about tinnitus annoyance in people who have newly developed tinnitus and its associated risk factors. Knowledge of risk factors that are associated with the occurrence of tinnitus and with distress people experience from their tinnitus is important for prevention and treatment. The aim of our study is twofold. 1) To analyze baseline factors that might be associated with the development of tinnitus after 5 or 10 years. 2) To evaluate factors associated with tinnitus annoyance in new-onset tinnitus.
Methods Baseline, 5-year and 10-year follow-up data of participants of the Netherlands Longitudinal Study on Hearing (NL-SH) were used. The NL-SH is a web-based prospective cohort study which started in 2006 and includes both normal hearing as well as hearing impaired adults aged 18 to 70 years at baseline. The NL-SH uses the National Hearing Test, which is an online digit-triplet speech in noise test to asses hearing ability. Online questionnaires on various aspects of life were filled in by participants. At follow-up, participants were asked 1) if they suffer from tinnitus and 2) to rate their tinnitus annoyance on a 1-100 numeric rating scale. For each of these two questions a multivariable prediction model was built, using logistic regression to assess development of tinnitus and linear regression with tinnitus annoyance as outcome in patients with newly developed tinnitus. Baseline risk factors were used for the outcome tinnitus at 5- or 10-year follow up, whereas annoyance of tinnitus was studied cross-sectionally (i.e. for annoyance at 5- or 10-year follow up, the value of the independent variables at that same follow-up moment was used). Possible predictors included in each of the two models were age, sex, education, living arrangement, history of smoking, alcohol use, hearing ability, a selection of diseases (which have cross-sectionally been associated with tinnitus in other studies), and the 4 Dimensional Symptom Questionnaire (assessing distress, depression, somatization, and anxiety). Using the univariable analysis as a pre-selection procedure (p<0.2), a multivariable model was built (p<0.1).The model was constructed with forward selection.
Results In total 788 participants without tinnitus at baseline were included. At 5- or 10-year follow-up 153 participants reported to suffer from tinnitus. Using univariable analysis, male sex, history of smoking, and somatization were independently associated with a higher odds ratio for developing tinnitus over time and included in the second step. The final prediction model revealed that sex (female, OR 0.61, 90% CI = 0.45 to 0.83, p=0.009) and somatization (0-21 scale) (OR 1.05, 90% CI = 1.02 to 1.08, p=0.009) were significant predictors of tinnitus. For the outcome tinnitus annoyance, univariable association were found with poorer hearing ability, high education), having osteoarthrosis, distress, depression, somatization, and anxiety. In the final prediction model, tinnitus annoyance is predicted by anxiety (scale 0-24; β = 1.3, 90% CI = 0.5 to 2.1, p=0.006), osteoarthritis (β = 7.9, 95% CI = 0.6 to 15.1, p=0.08) and high education (β = -10.9, 95% CI = -19.3 to -2.4, p=0.04, compared to low education).
Conclusion Somatization and being male were found to be predictors for developing tinnitus (incidence). Anxiety, osteoarthritis and being lower educated were found to predict a higher annoyance caused by tinnitus. Anxiety as a risk factor for developing tinnitus is a novel finding. It deserves to be addressed in future research and clinical practice. Lower educated participants may have less developed strategies to cope with tinnitus and therefore show a greater annoyance. Another explanation may be related to less educated people being informed more poorly about tinnitus. This might be ameliorated by the effect of counseling by a health care professionals or better access to proper information on tinnitus.

357 - Prevalence of tinnitus in a sample of 43,064 children in Warsaw, Poland

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Background Tinnitus affects both adults and children. Children rarely complain spontaneously of tinnitus, and their parents are not aware of the condition. The prevalence of tinnitus in children differs considerably between studies, and large studies are needed to reliably estimate how many children experience tinnitus symptoms. The goal of the study was to estimate the prevalence of tinnitus in a large sample of schoolchildren.
Material and Methods This study was population-based, epidemiological research, conducted in the general, pediatric population of school-age children in Warsaw, Poland. Results from 43,064 children aged 11 to 13 years old, as well as their parents, were collected. Pure-tone audiometric testing was done, and hearing thresholds were determined from 0.5 to 8 kHz. Both the children and parents answered questions about the presence of tinnitus in the child.
Results The study showed that tinnitus affected 3.1% of the children, but it was significantly more frequent (9%) in children with hearing loss. We found that 1.4% of the parents were aware of the presence of tinnitus in their children.
Conclusion Results of the study show that there is a need to introduce a routine question about experiencing tinnitus during pediatric check-ups. Particular attention should be paid in cases of children with hearing impairment because of the higher risk of comorbid tinnitus. Further management, if needed, should be conducted in appropriate pediatric settings by health care professionals who have the skills and knowledge to work with children.

387 - Influence of tinnitus annoyance on hearing related quality of life in cochlear implant recipients

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Background Tinnitus is the perception of sound without an external auditory input, often associated with aging and hearing loss. For cochlear implant (CI) recipients, there is no consensus on the impact of tinnitus on hearing-related quality of life. We hypothesized that hearing-related quality of life (QoL) in CI recipients is related to tinnitus annoyance.
Objective The aim of this study was to assess the relationship between hearing-related QoL measured by the Speech Spatial and Qualities of Hearing questionnaire (SSQ12) and tinnitus annoyance or perceived change in tinnitus annoyance with cochlear implantation.
Method The study sample consisted of 2322 implanted adults across France, Germany, Ireland, Italy, the Netherlands, Sweden and the United Kingdom. Hearing-related QoL, measured using the SSQ12, tinnitus annoyance and change in tinnitus annoyance, assessed using single-item questions, were acquired one or more years post-implantation. The relationship between SSQ12 total score and tinnitus annoyance or change in tinnitus annoyance was analyzed using linear models adjusted for age and implant configuration (unilateral, bilateral). Tukey pairwise tests were used to compare tinnitus levels.
Results Tinnitus prevalence was 33.9% post-implantation. This prevalence varied significantly with age (Chi square test, p=0.034). Recipients with tinnitus had significantly lower SSQ12 scores than recipients without tinnitus (mean difference 0.71 (SD: 0.09) SSQ12 units, F-test, p<0.0001). SSQ12 scores decreased significantly with age, tinnitus annoyance (linear model, p<0.001) and perceived change in tinnitus annoyance (linear model, p<0.001). Recipients rating their tinnitus as *not at all bothersome* had significantly higher SSQ12 scores than recipients with higher tinnitus annoyance levels (*quite a bit bothersome*: mean difference 1.23 (SD: 0.26) SSQ12 units, Tukey test, p<0.05, *moderately bothersome*: mean difference 1.32 (SD: 0.27) SSQ12 units, Tukey test, p<0.05, *extremely bothersome*: mean difference 2.36 (SD: 0.34) SSQ12 units, Tukey test, p<0.05). Recipients reporting that their tinnitus was *much more bothersome* since implantation had significantly lower SSQ12 scores compared with those rating their tinnitus as *much less bothersome* (mean difference 1.62 (SD: 0.29) SSQ12 units, Tukey test, p<0.0001).
Conclusion Overall, CI recipients who experienced less bothersome tinnitus showed better self-reported hearing related QoL. The association of better hearing performance with a positive change in tinnitus with cochlear implantation should be explored further.
Key words: cochlear implant, tinnitus, hearing-related quality of life, speech spatial qualities of hearing scale, age effect

388 - Sound therapy for cochlear implant users with tinnitus
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Objective Despite the positive effect of a cochlear implant (CI) on tinnitus in many patients, tinnitus remains a problem for a significant proportion of CI users. We investigated the acceptability and effect of sound therapy (a combination of natural background sounds and one concise tinnitus counselling session) on tinnitus and speech perception in CI users who still experienced tinnitus during CI use.
Design and study sample Thirty-two CI users (32–78 years) participated in phase 1: a test at the clinic to evaluate six background sounds provided by the sound processor. Eighteen out of the 32 CI users participated in phase 2: an optional take-home evaluation of 2 weeks without sound therapy, followed by 5 weeks with sound therapy, ending with an evaluation visit.
Results Thirty subjects (93.8%) found at least one background sound acceptable. In phase 2, a small improvement with sound therapy was found for tinnitus loudness, annoyance, and intrusiveness. 50% of the subjects subjectively reported benefit of sound therapy. Especially the sense of control on their tinnitus was highly appreciated. No detrimental effect on speech perception was observed.
Conclusion The background sounds were acceptable and provided tinnitus relief in some CI users with tinnitus during CI use.
Key words: background sounds, cochlear implants, speech perception, tinnitus

Special Session
SPEECH-IN-NOISE TESTING WITH DIGITS IN NOISE
Organized by Cas Smits

313 - hearWHO app: a WHO effort to promote access to hearing care globally
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Medical Officer of World Health Organization [(1)]

Globally, over 460 million people have hearing loss that can be addressed through timely interventions. Majority of them live in low resource settings where access to diagnostic and rehabilitative services is often limited. Even those living in high income countries often fail to seek hearing care services due to ignorance or attitude. To address the issue, WHO has developed the hearWHO app which is based on validated digits-in-noise technology. The free app has a two-fold aim. It aims on one hand to raise awareness on hearing loss and encourage people to check their hearing as a first step in hearing care; and on the other hand to improve access to a simple and validated test in community settings. The hearWHO*pro* serves the second aim and can be used by health workers to check hearing in their communities and guide those failing the test to seek diagnosis and interventions. Used by over 130,000 people in all regions of the world, the app is currently being translated into five other languages as a means for increasing its global reach and impact.

314 - Uses of digits in noise testing in large population studies and clinical trials

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Speech in noise (SiN) hearing assesses aspects of auditory perception that are of primary and specific importance for human communication. Digits in Noise (DIN) provides several key benefits. Target speech is a highly over-learned, small (0-9), closed-set of words having speech reception thresholds well correlated with pure tone audiometry, yet exerting considerable cognitive demand and having an ecologically realistic energy bandwidth. Wideband masking noise is typically speech-shaped, with or without modulation, and of sufficient energy and bandwidth to effectively mask ambient uncontrolled sound. DIN may be delivered at high fidelity online and through portable devices (e.g. smartphones), making remote screening and diagnosis possible without a sound booth or direct professional supervision. These features, together with a small and transient learning effect, enable large-scale population research and home-based clinical testing using DIN. Here, we highlight five diverse studies, two of which (UK Biobank and 23andMe) have enabled genome-wide association (GWAS) mapping to search for genetic involvement of SiN hearing in very large populations (~200,000). GWAS studies require exceptionally large data sets to adequately sample diverse genome involvement and complex behavioral traits such as speech hearing that typically involve 10s to 1000s of individual genes. A third study has targeted effects of leisure music exposure on high frequency (HF) hearing (MRC Centenary Study), finding no evidence in a large internet sample (~4,500) of mostly young adults for elevated SiN thresholds associated with high levels of venue or personal music experience. The ability to monitor experimental drug safety and efficacy longitudinally in clinical trials is currently being investigated in a collaborative study with hearX and Otonomy Inc. involving a candidate drug for prevention of cochlear neurodegeneration. In a final study, we are proposing to use DIN to monitor the hearing of patients with cystic fibrosis using repeated aminoglycoside antibiotics to manage bacterial infections. SiN monitoring can be used alongside pharmacogenomics, leading to personalized medicine. Since ototoxicity and noise- and age-related hearing loss typically affect HF hearing first, we are using variants of low-pass filtered masking noise to sensitize DIN to these common causes of hearing impairment.

309 - Digits in noise in a large cohort of older adults: associations with hearing thresholds and brain-related measures

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Age-related hearing loss is common in the elderly population. The Rotterdam Study is an ongoing prospective cohort study on healthy aging in which hearing loss is being studied among many other age-related disease. Since the last ten years, more than 7000 participants of 40 years and older have been tested for hearing. Next to pure-tone audiometry, the digits in noise test (DIN) is assessed with the aim to have a functional measure of hearing capacity.
An overview will be presented of the main results obtained with the DIN in the Rotterdam Study. First of all, we found a considerable high correlation between the speech in noise threshold and pure tone audiometry thresholds, confirming that the DIN is an appropriate hearing-screening tool in older adults. Another relevant finding is that a poorer speech in noise perception is associated to a poorer quality of structural brain measures, including white-matter volume and integrity. In a recent analysis we also found an association between the performance on the DIN and the prevalence of tinnitus. The DIN proofs to be a powerful tool to study hearing in large cohort studies such as the Rotterdam Study.

297 - Language independent hearing screening in childhood with digits and sounds in noise

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Childhood hearing screening is important as unidentified hearing loss causes higher risk for speech, language and learning impairments as well as the risk for low social communicative abilities. In most (European) countries, neonatal hearing screening programs (NHS) are implemented already, but in only few countries auditory screening exists beyond NHS. In Flanders, an extensive childhood screening program is implemented in which children are screened at 5 different moments. Since September 2016, the Digit Triplet Test (DTT) is successfully implemented in 6th year of primary school and 3rd year of secondary school. Highly reliable SRTs could be obtained in a limited amount of time, allowing accurate monitoring of hearing over time. However, for the screening of younger children, for example, at school entry, the DTT is not possible as it requires cognitive abilities that are not present at these ages. Moreover, the DTT is language dependent which hinders standardization within and between countries. Therefore, research is ongoing to an alternative, language-independent screening test for younger children. A proof of concept is already set with the Sound Ear Check (SEC) which is an automated sound-in-noise screening on tablet that uses eight highly familiar sounds (e.g. barking of a dog). The concept of the SEC has been studied in adults, giving very promising results. Therefore, research on further development and optimization will be conducted, aiming at self-administration by young children and application across countries and cultures. Details and preliminary results of those studies will be presented at the meeting.

301 - Testing CI users with digits in noise

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The digits-in-noise test (DIN) is well known as an online self-adminstered hearing screening test. Less well recognized is it's value as a diagnostic test in the clinic. In this presentation an overview of studies and clinical data from Amsterdam UMC, location Vumc, will be presented concerning the use of the DIN in CI users. Clinical data from adults show that, for good performers in quiet, the variability in speech-in-noise recognition is huge. On average, young implanted children perform better than adults but still scores are lower than scores from normal-hearing children. Study results show the advantage of bilateral implants over a CI-cros option. In other studies it was demonstrated that CI users can benefit from interuptions in the masking noise, but they don't experience binaural unmasking. Finally, results will be presented from studies in which a self-administered home test for CI users was developed and evaluated. The home test provides a valid alternative to DIN testing in the clinic and showes finegrained details of progress in speech-in-noise recognition during the first months after initial activation.

308 - Using the digits-in-noise test to triage hearing loss types

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The digits-in-noise test (DIN) is a popular self-test measure that has traditionally been used to screen for hearing loss by only providing either a *pass* or *refer* result. Standard approaches tested either monaurally or used a binaural diotic version where identical digits and noise were presented simultaneously to each ear. Recently, an antiphasic version was developed, increasing sensitivity of the DIN to unilateral or asymmetric sensorineural hearing loss (SNHL) and conductive hearing loss (CHL). We evaluated whether a combination of diotic and antiphasic DIN could accurately classify hearing as (a) normal, (b) bilateral SNHL, or (c) unilateral SNHL or CHL. The sample consisted of bilateral normal hearing (*n*=293), bilateral sensorineural hearing loss (SNHL; *n*=172), unilateral SNHL (*n*=42) and CHL (*n*=32). Each (*n*=489) participant first completed an antiphasic DIN (digit stimuli 180^{o} out-of-phase between ears), while 393 of the sample also completed a diotic DIN. Two procedures were assessed for their ability to categorize hearing into one of the three hearing groups. The first used fixed antiphasic and diotic DIN SRT cut-offs, while the second used a variable, diotic DIN SRT cut-off, to maximize the percentage of correctly categorized participants. The first fixed SRT cut-off procedure

could correctly categorize 75% of all participants, while the second procedure increased correct categorization to 79%. False negative rates for both procedures were below 10%. A sequential antiphasic and diotic DIN could categorize hearing into three groups of (a) normal hearing, (b) bilateral SNHL, and (c) unilateral asymmetric SNHL or CHL to a reasonable degree. This type of approach could optimize care pathways using remote and contactless testing, by identifying unilateral SNHL and CHL as cases requiring medical referral. In contrast, bilateral SNHL cases could be referred directly to an audiologist, or non-traditional models like OTC hearing aids.

378 - Digits Triplet Test (DDT) in Cochlear Implant Users and Normal Hearing Listeners
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Speech perception battery for evaluating auditory function among cochlear implants (CI) candidates and users includes tests of different levels (e.g., closed and open set) and conditions (quiet, noise). As the hearing-impaired population undergoing cochlear implantation expands, the need grows for sensitive and effective speech perception tests that are brief and accurately reflect the auditory function of CI users in daily listening conditions. Over the last decade, the Digits Triplet Test (DTT) was developed and validated in many languages (including Hebrew). The DTT is a quick test (a few minutes) with a very low linguistic requirement, and is tested under noise conditions. The current study: (1) conducted a comparison of DTT performance across ages in different populations of CI users (prelingual and postlingual) and normal hearing (NH) peers; and (2) tested the correlation between standard speech perception and cognition tests with the DTT. Ninety subjects participated: 30 children aged 5-10 years (15 CI users, 15 NH), 30 young adults aged 13-30 years (15 prelingual CI users, 15 NH), and 30 adults aged 22-70 years (15 postlingual CI users, 15 NH). Speech perception tasks included the DTT, one-syllable word test, and sentence identification task in quiet and noise conditions. Participants also completed auditory forward and backward digit span tasks. Our findings showed the following:(1) poorer performance on the DTT for all CI users across populations and ages compared to NH peers; (2) a developmental trend on DTT thresholds for CI and NH children (3) for adult post-lingual CI users, a high correlation only between the sentence in noise test and DTT results; (4) for young adult prelingual CI users, high correlations between speech perception in quiet (words and sentences) and DTT results, and between forward digit span test and DTT results; and (5) among children (CI and NH), high correlation between the sentence in quiet test and DTT results. The current findings indicate that CI users (prelingual and postlingual, children and adults) required a mean of 6dB higher signal-to-noise ratio (SNR) than their NH peers to repeat digits in noise, and that the DTT can serve as a simple, rapid test requiring minimal linguistic background for prediction of CI speech perception outcomes.
Key words: Digits in noise, DTT, speech perception, cochlear implants

AMPLIFICATION – TECHNOLOGIES AND STRATEGIES

397 - Active hearing aid program, self-reported listening environment, & listener satisfaction – What can we learn from smartphone collected data?
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Commercially available hearing aids are capable of capturing and analyzing the acoustical environment a listener is in, as sound is captured by the hearing aid microphones. This can inform hearing aid settings tailored to the environment, and potentially, switching automatically between settings when the acoustical environment changes. Information regarding the active hearing aid program can thus provide objective information regarding the complexity of the listening environment at any given time. That said, real life communication is much more than the mere complexity of the acoustical environment. In some cases, for instance, the acoustical environment and a listener's listening intentions may match up, e.g., the listener is in a quiet environment and is communicating with a significant other about their day. In other cases, the acoustical environment and a listener's listening intentions may not match up, e.g., the listener is driving a car while communicating with a significant other, or the listener is driving a car and singing along to music on the radio.

The aim of this retrospective data analysis is to explore how listeners self-describe the listening environments they are in, how these descriptions correspond to the active hearing aid programs, and how listeners rate their listening experiences in those moments. We will present preliminary results of 30,127 listener ratings, collected over a period of 2.5 years through a smartphone application available to users of commercially available hearing aids. The results will give us valuable insights on the perspectives of users and provide a foundation for future research and continuous development of hearing solutions.
Keywords: hearing instruments, environmental classifier, digital solutions, user centered care

469 - Individual Life-Course Socioeconomic Position and Hearing Aid Use: A Social Epidemiological Perspective on Hearing Care Disparities
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Purpose Over 1.5 billion individuals globally have some degree of hearing loss, which equates to approximately 20% of the global population, and the number is expected to increase to almost 2.5 billion by 2050. In the United States (US), age-related hearing loss is highly prevalent, affecting 2/3rds of adults 70 years and older. While highly prevalent, management of hearing loss, from testing to the use of hearing aids, is low, where only 15-20% of older adults with hearing loss in the US use hearing aids. Furthermore, disparities in hearing care exist by race, ethnicity, socioeconomic position (SEP), and rurality, among other factors. Nationally, only around 10% of older adults who self-identify as African American or Mexican American and have an audiometric hearing loss use hearing aids. Recent international efforts, including the 2021 World Health Organization's *World Report on Hearing*, highlight reduction of hearing care disparities as a public health priority.
Previous research on hearing care disparities by SEP has largely focused on income and education. However, there has been a growing understanding of life-course SEP as a more comprehensive and cumulative measure of SEP in relation to disease- and care-related outcomes. Life-course SEP incorporates measures of parental SEP in childhood, as well as income, education, home ownership, and occupational role in young and older adulthood. Although the association between life-course SEP and various disease-related outcomes has been explored, previous studies have not examined the association between life-course SEP and hearing health care behaviors, such as hearing aid use. Given that life-course SEP incorporates socioeconomic measures across multiple stages of life, it may offer a more nuanced and robust understanding of socioeconomic influences on hearing aid use as a health behavior, particularly among older adults and may inform interventions to address disparities.
Method To measure the association between individual life-course SEP and hearing aid use, we examined childhood and adulthood socioeconomic variables collected at the Atherosclerosis Risk in Communities (ARIC) study baseline visit (1987–1989)/Life Course Socioeconomic Status study (2001–2002) and hearing aid use data collected at visit 6 (2016–2017). ARIC is a prospective cohort study of older adults (45–64 years) recruited from 4 US communities. This analysis included a subset of 2,470 participants with hearing loss at visit 6 (≥25 decibels hearing level [dB HL] better-ear) with complete hearing aid use data. Childhood SEP variables included parental education, parental occupation, and parental home ownership. Young and older adulthood SEP variables included income, education, occupation, and home ownership. Each life epoch was assigned a score ranging from 0 to 5 and then summed to calculate the individual cumulative SEP score. Multivariable-adjusted logistic regression was used to estimate the association between individual cumulative SEP and hearing aid use. Missing SEP scores were imputed for participants with incomplete socioeconomic data.
Results & Discussion Of the 2,470 participants in the analytic cohort (median [interquartile interval] age 79.9 [76.7–84.0], 1 330 [53.8%] women, 450 [18.2%] Black participants), 685 (27.7%) participants reported hearing aid use. Higher cumulative SEP was positively associated with hearing aid use (odds ratio [OR] = 1.09, 95% confidence interval [CI]: 1.04–1.14), and slightly stronger for childhood (OR = 1.09, 95% CI: 1.00–1.20) than older adulthood SEP score (OR = 1.06, 95% CI: 0.95–1.18). Furthermore, in comparison to White participants, Black participants had lower odds of hearing aid use (OR = 0.35, 95% CI: 0.21–0.56).
In this community-based cohort of older adults with hearing loss after adjustment for age, demographic, and clinical factors, individual cumulative life-course SEP score was positively associated with hearing aid use. When examining by life epoch, individual SEP score was positively associated with hearing aid use, from

childhood through older adulthood. Our finding that childhood measures of SEP are associated with hearing aid use in older age highlights the importance of using a life-course approach that extends beyond SEP in older age to understand and address hearing health care disparities.
Keywords Hearing care disparities, Social epidemiology, Life course approach, Socioeconomic position

456 - Smartphone-connected hearing aids for all? Results of a qualitative study underpinned by the Behaviour Change Wheel
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Background and aim: Smartphone-connected hearing aids are increasingly available. Whilst there is ample published evidence as to the experiences of patients using these, there is a paucity of evidence regarding how clinicians can prime and support patients through adoption and use of these devices.
The present study aimed to use the Behavior Change Wheel to provide a theoretically underpinned analysis of patient experiences of smartphone-connected hearing aids that are directly mapped to strategies clinicians can implement to facilitate use and reduced barriers around smartphone-connected hearing aids.
Design: Participants in the present study were conveniently sampled from a previous 7-week trial of 44 smartphone-connected hearing aids in everyday life, conducted at a single-centre using an observational design. Eight participants (1 new hearing aid user and 7 existing hearing aid users, mean age = 71.75 years, SD = 5.23, range = 65 to 81 years) took part in one of two concurrent focus groups.
Each focus group utilized a schedule of questions, were dual moderate and were audio recorded and transcribed. Transcripts were thematically analysed using a three-stage approach. The first stage used thematic analysis to inductively generate codes and mapped these to the COM-B and Theoretical Domain Framework models. The second stage mapped themes to the intervention functions of the Behavior Change Wheel and in stage three the mapped intervention functions were used to identify specific behavior change techniques from the Behavior Change Technique Taxonomy (BCTT, version 1) that could be utilized to encourage app use and minimize barriers.
Results: Capability: Use of smartphone-connected hearing aids increased the knowledge individuals had on hearing aid features and controls. Whilst some app features were novel, the main benefit was the app aided awareness of controls and helped them advocate for what is helpful. It is hypothesized that the visual nature of the app controls and immediate evaluation opportunity helped participants to understand which features were optimal to them. A noted barrier was the increased cognitive load some felt in deciding when to use the smartphone app to alter settings or which control to adjust. The resulting BCCTs include the use of action plans or habit formation to maximize understanding of features and minimize the cognitive burden reported.
Opportunity: Participants reported a strong societal norm regarding smartphone-use. For example, several described situations where they felt it would be unacceptable to use their phone as it could be mis-perceived or draw attention to them. Whilst some saw this as an opportunity to discuss their hearing loss and this facilitated app use, others felt perceived norms were a barrier to app use. Participants spoke of experiential learning, whereby they selected the situations in which they found the app to be most effective. For some existing hearing aid owners the benefits of self-adjustment were stark; they were able to access and participate in situations previously difficult with their audiologist programmed devices. Consequently, the BCCTs included clinicians exploring situations where smartphone use might be optimal and provision of practical and emotional support to patients.
Motivation: Use of smartphone-connected hearing aids empowered participants in hearing loss self-management. This cascaded to benefit family members and also helped to reduce the perceived self-stigma of hearing loss for some participants. Participants reported the devices have the potential to change societal stigma towards hearing aids. Some noted a perceived generational difference in which they felt 'younger' adults would benefit more. This juxtaposed the use reported and suggests that there may be unfounded beliefs around smartphone abilities in this population. Accordingly, BCTTs identified how clinicians might look to educate current and prospective users on the benefits and limitations of smartphone-connected hearing aids. It is hypothesized that through appropriate enablement and support any who wish to use smartphone-connected hearing aids should have the opportunity to do so.
Conclusion: Smartphone-connected hearing aids provide multiple benefits to empower and enable hearing loss self-management. Whilst there are barriers, many are modifiable e.g. unfounded perceptions around age and smartphone capabilities. The suggested BCCTs are aimed to facilitate the use of smartphone-connected hearing aids and educate current and prospective users on the barriers and potential mitigations to these. The

study advocates that smartphone-connected devices should be offered to all adults who can and are willing to trial these devices.

284 - Leveraging Task Sharing & OTC Hearing Technology to Increase Access: Lessons from HEARS

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Purpose Age-related hearing loss is highly prevalent, affecting 2/3rds of adults 70 years and older. Although hearing loss is increasingly recognized as core to health, function, and well-being for individuals, families, and societies, traditional clinic-based hearing care has not adequately addressed the growing global burden and disparities in care exist. Recent national and international efforts, including the 2020 WHO World Report on Hearing, highlight reduction of hearing care disparities as a public health imperative. Directly resulting from such efforts, national-level legislation passed in the United States in 2017 created the designation of over-the-counter (OTC) hearing aids, which are expected to debut on the consumer market in 2020. To meet the global burden of hearing loss among older adults, affordable, accessible technologies, such as OTC hearing aids, along with the implementation of task sharing, through the incorporation of community health worker (CHW) models, aim to improve hearing care access, particularly for vulnerable populations. The application of public health approaches, such CHW models, and OTC hearing technologies is critical to realizing the promise of community-delivered hearing care and the vision of accessible hearing care for all laid out in the 2020 WHO World Report on Hearing.
Method Through a community-engaged development process, we developed the *HEARS* intervention, which is designed to be delivered by CHWs, specifically older adult peed educators. The *HEARS* model maximizes accessibility through multiple domains, including peer-to-peer mentoring, theory-driven methods to enhance self-efficacy, incorporation of principles of designing for older adults, and low-cost, user-centered OTC hearing technology and instructional materials. We conducted a prospective, randomized control pilot, with a 3-month delayed treatment group as a waitlist control, that assessed feasibility, acceptability, and preliminary efficacy of this first-in-kind community-delivered, affordable, and accessible intervention for older adults with hearing loss. Outcomes were assessed at 3 months, comparing immediate and delayed groups, and pooled to compare the cohort's pre- and 3-month post-intervention results.
Results & Discussion All participants completed the study (n=15). The program was highly acceptable: 93% benefited, 100% would recommend the program, and 67% wanted to serve as future program trainers. At 3 months, the treated group (n=8) experienced fewer social and emotional effects of hearing loss and fewer depressive symptoms as compared to the delayed treatment group (n=7). Pooling 3-month post-intervention scores (n=15), participants reported fewer negative hearing-related effects (effect size=-0.96) and reduced depressive symptoms (effect size=-0.43). Utilizing low-cost, over-the-counter listening devices, delivered in the community, the mean change in hearing handicap and the effect size compares to improvements seen with hearing aids provided through traditional clinic-based care models. Following the development of a user-centered train-the-trainer program, older adult peer educators (n=2) were successfully trained to provide the *HEARS* intervention and achieved comparable results. The *HEARS* intervention is feasible, acceptable, low-risk, and demonstrates preliminary efficacy and is currently undergoing a larger, randomized controlled trial. Lessons learned from *HEARS*, which relies of OTC technologies, used by older adults, taught by older adults, provides critical insights to the general advancement of technology access and use by older adults and the application of task sharing to hearing care.
This presentation will share the lessons learned from HEARS, including the pilot study as well as the larger randomized controlled trial (n=151) of the HEARS intervention currently underway in the United States. The discussion will couch the lessons within the WHO World Report on Hearing to advance the potential for community-delivered hearing care in caring for older adults across diverse resource settings.

344 - Hearing aid usage among Asian American population during the Pandemic

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Objectives: The COVID-19 pandemic has been affecting our lives in many ways. Many elderly patients with various degrees of hearing loss have expressed a decrease in hearing aid usage due to shelter in place and stay at home orders. We aim to report the daily usage of hearing aids before and after the Pandemic in Asian American population and its relationships to their degrees of hearing loss.
Method: 92 patients aged 54 – 93 who were fitted with hearing aids were surveyed at a busy ENT practice in San Francisco. Patients were asked about their daily hearing aid usage before and during the Pandemic. Pure tone averages of these patients were computed using audiograms obtained before and during the Pandemic.
Results: More than half of the patients expressed a decrease in daily hearing aid usage during the Pandemic. Reasons for the decrease in hearing aid usage include shelter in place, decreased communication with friends and family members, inconvenience of usage with mask wearing especially with behind-the-ear and receiver-in-the-ear devices. Hearing aid usage correlates with the degree of hearing loss, with the severe to profound group averaged more than 10 hours of usage per day and mild to moderate group averaged less than 6 hours per day.
Conclusions: There is a general trend of decrease hearing aid usage during the Pandemic among elderly Asian population especially in the mild-to-moderate hearing loss group. As Shelter in place and lockdowns continue in many parts of the World, Hearing care professionals must take on an important role of counseling and encouraging hearing aid usage for our elderly and hearing impaired population.

233 - The Effects of Hearing Aid Experience and Gender in Terms of Amplification Satisfaction
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Purpose Satisfaction is essential to the hearing aid fitting process and it is frequently included as a measure of outcome by audiologists. The aims of this study were to compare subjective benefit between new and experienced hearing-aid elderly users; and to investigate the effect of gender on hearing-aid satisfaction of elderly users, in Greece.
Methodology The participants of this study were a group of sixty older adults with a bilateral diagnosis of moderate to severe sensorineural hearing loss, divided into two equal groups with fifteen men and fifteen women in each group. All participants received a complete audiometric evaluation and fitted bilaterally with digitally programmable hearing aids of various styles. None of the participants had a previous experience with hearing aids before the time of this survey. They completed the benefit/satisfaction subscale of a self-assessment outcome measure for hearing-aid users, the “Amplification Performance Outcome” that consists of six subscales. The first group completed it 4 weeks post-fitting and the second group 12 months post-fitting.
Results Overall, participants of both groups reported a significant level of satisfaction with their devices. There were no significant differences between experienced and new HA owners in terms of HA satisfaction, even though satisfaction ratings were slightly higher at 1 year compared to 1 month post-fitting. Additionally, no significant relationship was found between gender and satisfaction.
Conclusion Findings from this between-participant study suggest stable satisfaction ratings measured at 1 and 12 months post-fitting for both genders. These data are consistent with a number of other studies from other countries. However, although satisfaction measured at different times may be correlated, the effect of other variables may change it over time. Future studies with different age groups and larger sample sizes to track satisfaction longitudinally and its relationship with other intrinsic or extrinsic factors, may help to determine the most appropriate point post-fitting to administer satisfaction scales.
Key Words: Hearing Aids, Older Adults, Satisfaction, Greek

IMPROVING EHDI (1)

67 - Risk of hearing loss in very preterm discordant twins
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Objective: Discordant twins have an increased risk of mortality and mobility. We aimed to study the effect of birth weight discordance on the risk of hearing loss (HL) in very preterm twins.
Methods: Results of the two-stage Automated Auditory Brainstem Response nationwide Newborn Hearing Screening Program in Dutch Neonatal Intensive Care Units and diagnostic examination were centrally registered between January 2003 and December 2018 and included in this study. HL was defined as impaired when the Auditory Brainstem Response level >35dB (in one or in both ears) at diagnostic examination. We selected twins and singletons with a gestational age <32 weeks. Logistic regression analyses were applied to study the effect of discordance on the risk of HL. All effects were adjusted for birth weight (BW), gestational age and sex.
Results: In total, 3.017 twins and 20,150 singletons were available. The prevalence rates of HL were 6.5% (17/262), 5.6% (24/425), and 4.8% (31/644) in the smallest newborns of discordant twin-pairs with a difference in BW with their co-twin of >30%, >25% and >20%, respectively. These rates were significantly higher compared to concordant twin-pairs and singletons (range adjusted ORs=2.3-3.0, p<0.01). The largest newborn (>20%) of discordant twin-pairs showed a lower prevalence rate compared to singletons (adjusted OR=0.4, p=0.04). No other significant differences were found.
Conclusion: The smallest newborn of a very preterm discordant twin has an increased risk of HL, and the largest newborn seems to have a decreased risk of HL.

191 - Improved EHDI Efficiency and Adherence Through Patient Navigation: A Randomized Controlled Trial

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Background: The consequences of delayed diagnosis and failure to obtain timely intervention for infants with hearing loss include significant delays in language, cognitive, and social development with profound effects on education and employment. To promote early diagnosis and treatment, universal EHDI standards have been developed to promote the screening of infants no later than one month after birth, diagnosis of hearing loss before three months of age, and intervention for hearing loss initiated before six months of age (1-3-6 guidelines). The 2013 Joint Committee on Infant Hearing has placed a great priority on the development of interventions that promote adherence to the 1-3-6 guidelines because significant delays are present and many infants are lost to follow-up after abnormal infant hearing screening. EHDI programs have attempted to address non-adherence in follow-up; however, there is a lack of standardized and evidence-based approaches to decrease non-adherence to infant hearing testing and treatment. Non-adherence to obtain diagnostic testing has been addressed through patient navigator intervention programs within other areas of healthcare but has not been studied in hearing healthcare. Navigators are trained healthcare workers who are involved in assessing and mitigating personal and environmental factors involved to promote healthcare adherence and improve access to care. The objective of this research was to assess the efficacy of a patient navigator intervention to decrease non-adherence to obtain audiological testing following failed screening, compared to those receiving the standard of care.
Methods: Using a randomized controlled design, guardian-infant dyads, in which the infants had abnormal newborn hearing screening, were recruited within the first week after birth. All participants were referred for definitive audiological diagnostic testing. Dyads were randomized into a patient navigator study arm or standard of care arm. The primary outcome was the percentage of patients with follow-up non-adherence to obtain diagnostic testing. Secondary outcomes were parental knowledge of infant hearing testing recommendations and barriers in obtaining follow-up testing.
Results: Sixty-one dyads were enrolled in the study (patient navigator arm=27, standard of care arm=34). The percentage of participants non-adherent to diagnostic follow-up during the first 6 months after birth was significantly lower in the patient navigator arm compared with the standard of care arm (7.4% versus 38.2%) (p=0.005). The timing of initial follow-up was significantly lower in the navigator arm compared with the standard of care arm (67.9 days after birth versus 105.9 days, p=0.010). Patient navigation increased baseline knowledge regarding infant hearing loss diagnosis recommendations compared with the standard of care (p=0.004).
Conclusions: Patient navigation decreases non-adherence rates following abnormal infant hearing screening and improves knowledge of follow-up recommendations. This intervention has the potential to improve the timeliness of delivery of infant hearing healthcare and the overall efficiency of EHDI programs.

256 - Testing hearing in newborns 'early' - does it make a difference to audiology process and outcome?

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Background: Over the past two decades Universal Newborn Hearing Screening (UNHS) has been widely adopted throughout most developed countries, and most programs now have well established protocols including a recommended timeline within which a baby should progress through the hearing pathway from screen to intervention. One key milestone is the age at which a hearing screen is completed, with most programs aiming to screen all infants by one month of age. In reality, many infants have their hearing screened significantly earlier than this. This can facilitate earlier attendance at milestones further down the hearing pathway and brings with it a variety of challenges for both parents and professionals.
There is significant variation amongst published protocols regarding the recommended age for infants to commence diagnostic audiology following a screen refer. Some programs recommend an initial appointment within two weeks from the date of screen referral (unless the infant has not reached 38 weeks gestational age), while others require infants be between 4-8 weeks (corrected age). This can result in up to twelve weeks between a positive screen result and the commencement of audiological assessment.
The rationale for delaying audiology is to allow for maturation of the auditory response and associated implications for obtaining a clear and stable electrophysiological response, minimising further testing at a later date.
In contrast, paternal anxiety has been shown to increase with a longer delay in progression through the hearing pathway but was found to promptly resolve following a normal diagnosis.
Aims**:**
To examine whether infants seen for diagnostic audiology at a very young age (<44 weeks gestational age):

- require significantly more (or less) appointments to reach a final diagnosis
- are more likely to be diagnosed with not normal hearing
- are more like to have an initial diagnosis of permanent hearing loss which either improves or returns to normal by the final diagnosis

Methods: Setting: Victoria, Australia. Participants: Infants who participate in the statewide Victorian Infant Hearing Screening Program and are referred to one of 15 independent diagnostic audiology centres.
Measures: The Victorian Infant Hearing Screening Program (VIHSP) collects diagnostic information following each appointment, in most cases until the infant has progressed beyond electrophysiological testing. Each audiology centre has their own individual protocol regarding their preferred age to commence infant testing.
Analyses: This project uses population-based data to explore the relationship between age at first audiology appointment and various audiological parameters.
Results: Of the 2191 infants born between 2015 and 2017 who returned a positive result on their Victorian Infant Hearing Screening Program (VIHSP) newborn hearing screen, 2117 (96.6%) had valid diagnostic results available. Age at initial audiology appointment was categorised based on gestational age at the time of the appointment, with 1313 (62%) being aged less than 44 weeks.
For those infants with a final audiological diagnosis (n=2112) there was no difference in the number of appointments attended between those aged <44 weeks versus ≥44 weeks (mean 1.65 and 1.59 respectively (p=0.077) or the rate of diagnosis of normal hearing (58.0% and 55.6% respectively p=0.277).
For infants diagnosed with not-normal hearing, the proportion with a target hearing loss did not differ between the groups (9.6% in those aged <44 weeks and 10.2% in those aged ≥44 weeks (p=0.651)).
A small proportion (n= 21, 6.5%) of infants diagnosed with a permanent hearing loss at their initial appointment did show an improvement (>10dB) in their ABR click air conduction thresholds, with 4.7% having thresholds return to normal in at least one ear. Infants seen at a younger age were no more likely to have their hearing thresholds improve than their older peers. 6.8% of those seen at < 44 weeks and 6% of those seen at ≥ 44 weeks showed an improvement of more than 10dB in at least one ear.
Implications: Assessing infant hearing before 44 weeks gestational age does not appear to impact either the number of audiological appointments required to determine diagnosis, the likelihood of normal hearing being diagnosed or the likelihood that a permanent hearing loss will improve. These findings support the minimisation of time between newborn screening-referral and diagnostic audiology testing to minimise parental anxiety and facilitate timely access to early intervention services.
Key words: infant hearing, diagnostic audiology, auditory maturation

247 - The relationship between permanent hearing loss risk indicators and diagnostic audiology assessment results among infants referred on a newborn hearing screen

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Background: While the result on a newborn hearing screening test is integral to determining which infants require immediate audiological follow-up, additional clinical information relating to an infants' hearing health management is also routinely collected at the time of the screen. This typically includes the baby's gestational age, birth weight, multiplicity, and risk indicators associated with paediatric congenital and post-natal hearing loss. While the efficacy of universal newborn hearing screening (UNHS) in promoting early detection and intervention is established, there is an expectation that screening programs operate efficiently and cost-effectively. This project aimed to explore the relationship between permanent hearing loss risk indicators and diagnostic audiology assessment results among infants referred on a newborn hearing screen. A further aim was to determine if collecting risk indicator information within an established UNHS program could inform the audiological management of infants, and promote service efficiency across the screening pathway.
Methods: Setting: Victorian Infant Hearing Screening Program (VIHSP), Victoria, Australia Population: The study population comprised of 3134 infants born in 2015 -2019 in the state of Victoria who:

(i) returned a positive VIHSP newborn hearing screen result using a two-stage automated Auditory Brainstem Response (automated ABR) screening protocol, and
(ii) completed diagnostic audiological testing.

Measures: Risk indicators recorded at the time of the infants' newborn hearing screen were:
- severe jaundice at exchange transfusion levels
- meningitis or encephalitis
- ototoxic medication (e.g. aminoglycoside antibiotics) for three or more consecutive doses
- congenital abnormality of the head or neck
- close family history of congenital hearing impairment
- maternal infections during pregnancy
- syndrome known to be related to hearing loss
- ventilation for more than five days.

Diagnostic audiology results were based on confirmed (repeatable) results on a number of diagnostic audiological assessments, including Automated Brainstem Evoked Response, Auditory Steady-State Response, Otoacoustic Emissions, and Tympanometry. The target condition the UNHS program in Victoria aims to detect is permanent bilateral hearing loss of moderate or greater degree (more than 40dB HL in the better ear). Statistical analyses: Odds ratios were calculated to examine the relationship between the presence of a risk indicator and target hearing loss of infants referred on the newborn hearing screen.
Results: Of the total sample, 496 (15.8%) had at least one risk indicator for hearing loss. The most frequently recorded risk indicators within the cohort were ototoxic medication administration, close family history of congenital hearing impairment, congenital abnormality of the head or neck, and syndrome known to be related to hearing loss. Less commonly reported were ventilation longer than 5 days, maternal infection during pregnancy, meningitis/encephalitis, and severe jaundice. The prevalence of the target condition was higher when infants were identified with any risk indicator (n = 109/496; 22%) compared to those without a reported risk indicator (230/2638, 8.7%). Infants were more likely to be diagnosed with a target condition hearing loss if their risk indicators included close family history of congenital hearing impairments (odds ratio (OR) 5.6; 95% Confidence Interval (CI) 3.9-8.1),maternal infection during pregnancy (OR 3.9; 95% CI 1.5-9.9); ventilation longer than 5 days (OR 2.6; 95% CI 1.5-4.2); or ototoxic medication administration (OR 2.0; 95% CI 1.4-3.0).
Implications: Among newborn infants who do not pass their newborn hearing screen and have a risk indicator for hearing loss identifiable at the time of the screen, risk indicator information routinely collected at the time of newborn hearing screening may assist to identify those infants who may be most likely to have a permanent hearing loss requiring intervention. While risk indicators for hearing loss in newborns are primarily intended to identify infants who may go on to develop hearing loss after passing a newborn hearing screen, they may also assist to identify, at the time of diagnostic audiology scheduling, those infants who are most likely to require further intervention. The use of risk indicators has the potential to streamline UNHS program pathways to promote best use of diagnostic resources without compromising outcomes, and to maximise cost-effectiveness and efficiency.
Keywords: hearing loss, infant, screening, diagnostic audiology, risk indicators

490 - The contribution of automated auditory brainstem responses to newborn hearing screening

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Background and Objectives: Automated auditory brainstem responses (A-ABR) are routinely used in newborn hearing screening (NHS) programs. A-ABR testing is known to be less susceptible to middle ear problems than otoacoustic emissions thus incorporating this method in a two-stage protocol is expected to result in a reduction of false positive cases and unnecessary referrals. A-ABR testing is also known for its contribution in detecting auditory neuropathy spectrum disorders (ANSD) cases. On the other hand, A-ABR is less sensitive in detecting mild cases thus resulting in false negative cases. Thus, the aim of the present study was to examine the contribution of A-ABR testing in newborn hearing screening.
Methods: In order to assess the reduction of failure rates we retrospectively reviewed the NHS results of 94,575 newborns born at Sheba Medical Center between 2011 and 2019 and tested prior to discharge. Our NHS protocol is a two-stage protocol as recommended by the Israeli ministry of Health. All infants who fail two transient evoked otoacoustic emissions (TEOAE) tests are tested using A-ABR prior to discharge from the hospital and those who pass this test successfully and are not at risk for hearing impairment are discharged. High risk infants for auditory neuropathy are tested by both TEOAE and A-ABR and undergo diagnostic ABR 1-2 months after discharge as part of the follow-up. In order to assess the rate of false negative cases and that of ANSD cases we retrospectively reviewed the audiological records of 540 infants born with a family history of permanent childhood hearing loss during the period 2014-2019 who completed both screening tests and diagnostic ABR.
Results: Of the 94,575 infants who were tested prior to discharge, 94,345 infants (99.8%) underwent the full protocol. The failure rate following A-ABR testing was lower (1.4% - 1345/94345) than following one or two TEAOE tests (2.4% - 2,249/94,345). Thus, the inclusion of A-ABR testing resulted in a reduction of 40% in the failure rates. Comparison between each of the screening tools (TEAOE and A-ABR) separately and the diagnostic ABR testing revealed false negative cases for both screening tools. Specifically, 7/540 infants who passed TEOAE testing successfully were diagnosed with sensory-neural hearing loss (SNHL) (1.4% false negative rate) and 5/540 infants who passed A-ABR testing successfully were diagnosed with SNHL (0.9% false negative rate). All were mild or mild-moderate cases. None of the infants were diagnosed with ANSD.
Conclusions: Including A-ABR testing in a two-stage protocol significantly reduced the false positive rate and subsequent need for outpatient follow-up. Both TEOAE and A-ABR missed mild cases thus no screening test is perfect. The cases that were detected through diagnostic ABR raise the question of audiological follow-up protocols in high-risk infants.

IMPROVING EHDI (2)

66 - Bilateral hearing impairment after unilateral failure on hearing screening in Dutch Neonatal Intensive Care Unit graduates

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Background: From 1998 to 2002, a two-stage AABR Neonatal Hearing Screening Programme was gradually implemented for Dutch Neonatal Intensive Care Unit (NICU) graduates. Between 2003 and 2018, all NICU graduates were screened with Automated Auditory Brainstem Response (AABR).
Aim: To investigate the probability of bilateral hearing impairment after unilateral failure in newborns, and the effect of gestational age, birth weight and sex.
Methods: The two-stage AABR screening consists of a first AABR-test before discharge from the NICU towards a post intensive care/high care setting, and a second AABR-test at term age as outpatient if the newborn has failed the first AABR-test. All newborns who failed the two-stage AABR-test were referred for further audiological diagnostic procedures. Results of the screening and first diagnostic examination at the audiologic center were centrally registered until December 2018 in an electronic monitoring and registration system. Hearing Loss (HL) was defined as impaired when a diagnostic Auditory Brainstem Response (ABR) exceeded 35 dBnHL in one (unilateral) or two (bilateral) ears. We selected newborns who had a unilateral failure at the second AABR-test, a diagnostic examination at the audiologic center and no missing values on gestational age, birth weight and sex. Chi-square tests were performed to test the difference in the proportion of bilateral hearing impairment between subgroups.
Results: In total, 811 of 71,319 (1,1%) of screened NICU graduates had a unilateral failure at the second AABR-test. Of these 811 newborns, 719 newborns had a diagnostic examination at the audiologic center and no missing values on gestational age, birth weight and sex. A bilateral HL was detected in 225 of 719 newborns

(31%). Moreover, the proportion of newborns with bilateral HL was 35% in newborns with a gestational age < 32 weeks and 26% in newborns with a gestational age ≥32 weeks (p=0.013). No significant differences were found when stratified by birth weight and sex.
Conclusion: Our result strongly supports diagnostic evaluation of unilateral failures after AABR hearing screening in all high-risk newborns.

380 - Our experience using Melatonin and Tryptophan as an inducer of spontaneous sleep in children during ABR testing

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ABR is known as a gold standard test for the early diagnosis of hearing loss in children. One of the main difficulties is to achieve spontaneous sleep in order to reduce myogenic interferences.
Many studies demonstrate the effectiveness using Melatonin, a nutritional supplement, as a sleep inducer in diagnostic tests, without causing any side effects.
The aim of this retrospective study, initiated in June 2021, is to evaluate the effectiveness of using this nutritional supplement as a sleep inducer while performing ABR test in our paediatric population.
The study is performed on patients referred to the Barcelona Childrens Hospital of Sant Joan de Déu, which is the Reference Unit in Auditory Diagnosis of Catalonia (Spain). A solution which is composed of Melatonin, Tryptophan and Vitamin B6 is used when required, and a comparison between patients tested with and without the nutritional supplement is established, to verify its effectiveness in increasing the success of the testing.
ABR test with melatonin was performed in 49 children. All of their families were instructed to follow sleep deprivation recommendations before the test. 83% of those who followed the recommendations were able to complete the evaluation, while 55% could be performed on those who didn't follow the instructions given. The initial results of the study show that good quality sleep was obtained in 33 children (67%), brief sleep was obtained in 5 children (10%), who nevertheless remained quiet throughout the test, 6 children (12%) did not fall asleep and 5 (10%) were not reported. The mean sleep-onset time after administration of melatonin was 27 minutes with a mean sleep time of 33 minutes and a mean examination time of 44 minutes.
In addition, use of Melatonin slightly reduced the failure rate of all ABR tests performed in our Audiology Department. During the first half of the year, 14% of 316 patients could not undergo the test because they could not fall asleep or remain calm during the procedure, whereas once the use of Melatonin was implemented, only 10% of 348 could not undergo the test.
This study confirms the effectiveness of using the solution with Melatonin, Tryptophan and Vitamin B6 as an aid to induce sleep in paediatric patients when performing auditory examination with ABR tests. However, sleep deprivation of the patient is needed in order to increase its effectiveness.
Our Department continues with the study in order to obtain more data and verify these initial results.

352 - Organization and results of a hearing screening program in first-grade children of the Mazovian region of Poland

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Background Newborn hearing screening, which is presently undertaken in many countries, makes it possible to identify children with congenital hearing loss at birth, although other hearing impairments may not then be evident or may be acquired later on in childhood. Hearing screening of school-age children should be the prime tool for identifying hearing impairment that was not identified at birth or which developed later. Without mandatory routine hearing screening programs in schools, students with acquired hearing disorders may not be identified. The purpose of this presentation is to describe and assess a hearing screening program of first-grade children in Poland. The program aimed to detect hearing disorders as well as increase awareness among parents of hearing problems.

Materials and Methods The 2-year program consisted of 41 projects conducted in 37 districts and 4 towns in the Mazovian region in Poland. A total of 34 618 first-graders were screened. The hearing screening protocol included video-otoscopy and pure tone audiometry. The whole program was based on four main modules: an information campaign, educational meetings for parent/caregivers, seminars for local medical staff, and hearing screening examinations.
Results The estimated prevalence of hearing loss was 11%. Unilateral hearing loss was more common than bilateral hearing loss. Mild hearing loss was more frequent than moderate (or worse) hearing loss. In otoscopy the most common positive result was otitis media with effusion. Parents and medical staff took part in 1608 educational meetings, broadening the parents' knowledge of how to care for hearing. However, it must be said that no obligation or recommendation will help if parents are not aware of the importance of good hearing for their children and lack motivation to participate in hearing screening (by attending educational meetings, giving consent for testing, encouraging their children, and making sure they get tested). Non-attendance is a significant problem and a major limitation to the effectiveness of many health programs.
Conclusions A hearing screening program not only provides data on the prevalence of childhood hearing problems, but is also an avenue for providing the local community with valuable knowledge about how to care for hearing. This study demonstrated the importance for systematic monitoring of children's hearing status and of increasing awareness among parents and teachers of the significance of hearing loss. The hearing screening of children starting school should become a standard part of school health care programs.

185 - Improving Communication Between Hearing Screening Technologist and Nurses at CHOC Children's NICU

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Introduction: In the past five years CHOC Children's Hospital NICU has expanded from a single floor 54 bed unit to a 104 bed NICU spanning three locations in two hospitals. With this rapid increase in patients came a surge of NICU nurses not familiar with infant hearing screening (IHS) guidelines and processes. A communication gap was identified between NICU nursing staff and hearing screening technician from Diagnostic Services department leading to staff dissatisfaction.
Objective: To identify communication gap in infant hearing screening processes from both NICU nursing staff and Diagnostic Service technologists.
Method: A survey was developed by Diagnostic Service Leads, NICU Clinical Nurse Specialist and Neonatologist to assess both the nursing staff and technologists understanding of infant hearing screening guidelines and processes. The questionnaire consisting of four questions allowing for areas of response:

1. Is the Infant Hearing Screening (IHS) protocol hard to follow?
2. Should an IHS be performed on day of discharge?
3. Should an IHS be performed on day of discharge?
4. What are the contraindications for infant hearing screening?

Forty-three NICU nurses and 11 technologists from Diagnostic Services department participated in the study.
Results: Seventy seven percent of the nursing staff vs 50% of technologist responded tat HIS protocol is difficult to follow. Ninety seven percent of nurses vs 100% technologist responded that IHS should not be performed on the day of discharge. Sixty five percent of nurses and 100% of technologist were familiar with the required status of the baby for hearing screening to be performed. Sixty percent of nurses and 100% of technologist were familiar with the contraindication for hearing screening.
Based on the information gathered from the questionnaire, we developed an informational poster addressing the primary concerns of both the Diagnostic Services department and NICU. This poster has been displayed in all three NICUs, Diagnostic Services lab and is attached to the three portable Natus Infant Hearing Screening machines. Our expectation is the improvement in communication between the NICU Nursing staff and Diagnostic Service technologists.
Plan: We plan to resurvey the respondents in six months to gauge the level of improvement in communication.

406 - High frequency hearing in infants and toddlers born preterm

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Objectives: Infants born preterm are at higher risk for hearing loss, particularly in the high frequencies, due to ototoxic drugs, hypoxia-ischemia, mechanical ventilation and hyperbilirubinemia. However, current newborn screening methods that use click stimuli may miss slight-mild and high frequency hearing loss. These "minimal" losses are related to poorer language outcomes, however, there is a lack of evidence supporting hearing measures that are sensitive and specific for detecting these forms of hearing loss in infants.
Goal: This longitudinal study aims to improve prediction of speech, language and pre-literacy deficits in extremely and very preterm infants (≤ 32 weeks gestational age).
Methods: In this interim analysis, 42 preterm infants were tested at 3 months corrected-to-term age (range=2-5 mos.; male=27) and 78 toddlers were tested at 30 months corrected-to-term age (range=24-42 mos.; male=?). Test procedures included hearing history, otoscopy, 226 and 1 kHz tympanometry (test frequency was age dependent) and distortion product otoacoustic emissions from 2-10 kHz (Titan, Interacoustics). At 3 months, the auditory brainstem response (ABR) was measured using click (70 and 30 dB nHL) and level-specific CE-Chirp stimuli (1 and 8 kHz; Eclipse, Interacoustics). At 30 months, visual reinforcement (VRA) and/or conditioned play audiometry (CPA) using insert earphones was completed between 1-8 kHz.
Results: At 3 months, all infants had a detectable ABR to clicks at 70 dB nHL, however 46% had absent wave I and/or wave III or delayed wave III or V latency. Overall, 40% had bilateral or unilateral hearing loss; of these, 17% had conductive loss, 14% had sensorineural loss, 7% had mixed loss, and 2% were undetermined. The majority of infants with hearing loss had passed newborn screening. At 30 months, ear specific minimum response levels were obtained in 70% of children. Hearing loss greater than 20 dB HL in one or both ears was found in 22% of cases. Most hearing losses had a middle ear component (59%). However, a high percentage (35%) were considered sensorineural and 6% were undetermined.
Conclusions: An unexpectedly high proportion of extremely and very preterm infants and children had sensorineural or mixed hearing loss. Nearly half had abnormal click ABR morphology, potentially due to hearing loss, brain injury, or delayed neuromaturation. These results are novel and clinically relevant in preterm infants at risk for high-frequency hearing loss.
Supported by NIH/NIDCD R01DC018734 (Hunter, Vannest)

Lecture

461 - How can we leverage the World Report on Hearing (WHO) to minimize the impact of untreated hearing loss?

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In primary care, poor hearing is too much dismissed as “normal”.
When patients consult their general practitioner, in many cases they will hear “Gradually hearing less with age is a normal aging phenomenon” – “Hearing loss is part of getting older” – “Age-related hearing loss often develops so slowly that you hardly notice it yourself. It's a normal aging phenomenon.”
The issue is, that when hearing loss is described as being “normal”, most patients will conclude, that they don’t need to do anything about it.
In the WHO World Report on Hearing, developed by the World Health Organization’s Department of “Noncommunicable diseases” - programme for ear and hearing care in collaboration with experts and stakeholders in the field of ear and hearing care, the best available scientific evidence on ear and hearing care, the health care needs, human resource availability, current practices and recommendations for future actions are very clearly described.
In this presentation, we focus on the consequences of untreated hearing loss and the need for prevention, screening and early intervention with hearing care, which can be found in this World Report.

- The greatest challenge for people with unaddressed hearing loss is in maintaining communication with others in their environment
- An association between hearing loss and employment in adults is evident
- Hearing loss contributes to both social isolation and loneliness at all ages - Social isolation and loneliness due to hearing loss can have important implications for the psychosocial and cognitive health of older adults
- Across the life course, people with hearing loss commonly have higher rates of depression and report lower quality of life compared with their hearing peers
- Hearing loss is the largest potentially modifiable risk factor for age-related dementia

What does the World Report propose as action & intervention plan?

- Prevention – Make Listening Safe - the recommended level of sound exposure is below 80 dB for a maximum of 40 hours per week
- In older adults, hearing screening, followed by prompt hearing aid provision, is associated with significant improvements in hearing-related health outcomes.
- Adult hearing screening and early intervention become even more relevant given the links between hearing loss and dementia in older adults, and that addressing hearing through these devices may have a positive influence on an individual’s cognition.

No, hearing loss is not normal – we need to take it seriously.
Timely screening and intervention to avoid the negative consequences of untreated hearing loss are essential!
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OUTCOMES OF EHDI PROGRAMS

242 - Eight-year auditory follow-up after neonatal hearing screening in well-baby clinics in the Netherlands

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Introduction**:** In the Netherlands, a neonatal hearing screening program is implemented by the national health service and accessible for all Dutch babies. Healthy newborns are screened by oto-acoustic emissions (OAE) and/or by automatic auditory brainstem response (AABR) testing. After referral, diagnostic audiometry will be performed at dedicated speech and hearing centers. This study investigates the predictive value of the initial neonatal auditory brainstem response (ABR) findings, with regard to severity and type of hearing loss (HL) at 1-2 years (visual reinforcement audiometry, VRA) and at 4 and 8 years of age (pure-tone audiometry).
Methods**:** Between 2004 and 2010 follow-up data of VRA at 1 and 2 years, and pure-tone audiometry (PTA, average frequencies 1, 2 and 4 kHz) at 4 and 8 years were collected for 106 well-born babies from a single speech and hearing center (Pento Zwolle, the Netherlands). The Two One-Sided Tests equivalence procedure for paired means was applied with the magnitude of the region of similarity equal to 10dB nHL.
Results**:** In total 172 were referrals were investigated after neonatal screening. In 5 cases we found permanent conductive HL, in 53 cases sensorineural HL (of which 13 unilateral and 40 bilateral) and in 48 cases temporary conductive HL. For the cases with sensorineural HL, it was found that ABR levels were equivalent (within a range of 10dB) with VRA at 1 and 2 years and the PTA at 4 and 8 years of age.
Conclusion**:** The 8 years follow-up of well-born babies showed that ABR is a good predictor for both the type and severity of HL.

56 - 19 years of the Polish Universal Neonatal Hearing Screening Program

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The Polish Universal Neonatal Hearing Screening Program (PUNHSP) has been running in Poland for over 19 years and it is the biggest preventive health Program in Poland. It was created as a civil initiative with the cooperation of a charitable organization, The Great Orchestra of Christmas Charity Foundation, and the cooperation of neonatologists, otolaryngologists and audiologists. The Polish Program is based on three levels: early detection of hearing loss, audiological diagnosis and intervention. By November 2021, there were 6 940 173 children registered in the Program. The database represents 97% of the newborn population in Poland. On average, 8.8% (609 582) of children who had been tested on I level were referred for further diagnosis. The median age of the diagnosis during the analyzed period was 84 days. According to the Central Database of the Program, about 75-85% of children who had been referred for further tests are recorded and diagnosed in laryngological centers. Hearing loss above 20 dB was recorded in 16 885 children. It is estimated that this occurs in about 2 per 1000 children born in Poland. Bilateral sensorineural hearing loss was diagnosed in 64.9% children, conductive in 22.4% children and mixed in 12.7% children. In contrast, single-side sensorineural hearing loss was diagnosed in 48.8% children; conductive in 38.2% children; and mixed in 13% children. All children, that are diagnosed with hearing loss are referred to the III level centers in order to undergo treatment, including fitting a hearing aid – 60,6% of children, rehabilitation - 29% of the children or surgical treatment - 10% of the children.

492 - The Impact of the Coronavirus Pandemic on the Neonatal Hearing Screening Program in Belgium

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Background Since early 2020 SARS-CoV-2 virus has been spreading rapidly all over the globe. From February 2020 onward, Belgium was also hit by the viral pandemic with an exponentially increasing number of COVID-cases. In order to control viral circulation, Health authorities installed strong restrictive guidelines, imposed limited physical contacts, meetings, gatherings, and issued non-pharmacological protective measures. All non-urgent healthcare activities were shut down. A complete lockdown started March 18th, 2020 and at the same time mandatory non-pharmacological interventions were in force (e.g. limiting physical appointments and contacts, social distancing, mask, strict hygienic measures). In order to avoid a rebound increase in morbidity, the preventive medical and screening program was only interrupted a few days and hence continued under strict application of the new rules.
Objective We aimed to explore the effect of the coronavirus pandemic and the national lockdown on the hearing screening program in Flanders- Belgium.
Method All data were extracted from prospectively collected electronic data files. Registered parameters were: characteristics of infants & mothers, coverage and dates of screening, intervention and outcome. The epochs before and during lockdown, and subsequently the 2nd, 3rd and 4th wave of pandemic were analyzed and compared.
Results Characteristics of the families and infants covered by systematic screening was comparable in control versus lockdown epochs (March 19th - April 30th 2019 versus 2020 = 61 vs 43 days): infants screened (10204 and 237/day vs 10137 and 327/day), proportion of underprivileged parents (14,1% vs 13,8%) and foreign & underprivileged families (9,5 %vs 9,8%).
Pre-screening home visits, intentionally strongly limited during lockdown, resulted in a significant difference (9741 (95,5%) 160/day vs 795 (7,8%) 18/day; p<0,0001) but numbers and coverage of screening at the day-care clinics did not (9799 (96,0%) vs 9867 (97,4%)), although at a significantly later age (22,6 +/- 14,8d vs 29,5 +/- 12,3d ; mean +/-SD; p<0,0001).
Numbers of infants referred because of failed screening at the daycare clinics differed (114 (1,16%) vs 65 (0,66%)), they were referred after a longer delay (13,8 +/-14,9d vs 15,3 +/-31,1d; mean +/SD). Diagnostic categories varied non-significantly (no hearing loss: 37 (41%) vs 22 (35%); conductive: 38 (42%) vs 17(27%); sensorineural: 14 (15%) vs 10 (16%)). A catch-up in home visits was observerd, and a statistically non-significant variation of the screening program during the successive eras.
Conclusion The hearing screening program in Flanders has been preserved during lockdown. Nevertheless, infants were screened at significant later postnatal age and the accompanying pre-screen visits diminished importantly. Subsequent waves of the corona pandemic had little or no impact on the screening program.
Keywords: Neonatal, hearing screening, coronavirus pandemic, SARS-CoV-2

68 - Twenty-year quality assurance of newborn hearing screening in Dutch neonatal intensive care units

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Objective: To evaluate 20-year quality assurance of newborn hearing screening (NHS) in Dutch neonatal intensive care units (NICU).
Methods: Results of the two-stage automated auditory brainstem response (AABR) screening and diagnostic examination in NICU graduates were centrally registered between October 1998 and December 2018. This registration facilitates screening, tracking and follow-up after abnormal screening results. Outcome measures are referral rates, prevalence rate of hearing loss, coverage rates and timeliness of follow-up, overall and trends in 5-years periods (1998-2003, 2004-2008, 2009-2013, 2014-2018).
Results: Seventy-thousand three hundred and thirty two newborns have been screened. Overall, referral rates were 12.6% at the first and 22.5% at the second stage. Hearing loss was diagnosed in 1,845 newborns (2.6%). Of these newborns, 1,368 (74%) had a bilateral hearing loss and 477 (26%) an unilateral hearing loss. Coverage rates were 98.9% at the first, 95.1% at the second stage and 94.3% for the diagnostic examination. After correction for gestational age, 95.7% of the newborns had their first AABR<1 month, 84.2% of the referred newborns had their second AABR<6 weeks and 72.1% were diagnosed<3 months. The positive predictive

value of hearing loss after AABR screening was 66.8%. Coverage rates increased over time in 5-year periods: 98.7%, 98.8%, 98.9%, 99.2% at the first, 90.8%, 93.1%, 96.4%, 96.9% at the second stage and 92.0%, 92.6%, 94.5%, 96.1% for the diagnostic examination. No trends were seen in the proportion of newborns who had their first AABR<1 month. The proportion of referred newborns who had their second AABR<6 weeks increased over time in 5-year periods: 79.5%, 83.6%, 85.3%, 85.6%. The proportion of newborns who were diagnosed<3 months increased between the periods 1998-2003, 2004-2008 and 2009-2013 (60.7%, 72.1%, 75.6%) and slightly decreased in the period 2014-2018 (73.9%). The positive predictive value of hearing loss after AABR screening was: 75.4% in 1998-2003, and decreased between the periods 2004-2008, 2009-2013 and 2014-2018 (79.5%, 64.6%, 58.3%). However, the proportion of hearing loss increased between these three periods: 2.1%, 2.7% and 3.0%.
Conclusion: The NHS in Dutch NICU's is effective over a long period. Positive trends were seen in most of the quality outcomes.

409 - Universal Newborn Hearing Screening in Victoria, Australia: The Victorian Infant Hearing Screening Program

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Background The Victorian Infant Hearing Screening Program (VIHSP) in Victoria, Australia, provides universal newborn hearing screening to all eligible newborns using automated auditory brainstem response (ABR) technology. VIHSP aims to facilitate improved outcomes for babies diagnosed with permanent congenital hearing impairment (PCHI) via the early detection of permanent congenital bilateral moderate-profound hearing loss in babies to thus enable early intervention. This study aims to: 1) briefly describe the evolution of VIHSP universal newborn hearing screening (UNHS); 2) describe the current operation of VIHSP; 3) evaluate VIHSP performance between 2012 and 2020 against key performance benchmarks and best practice guidelines; and 4) compare VIHSP screening technology and the target condition against other newborn hearing screening programs within Australia and New Zealand.
Methods This study used a mixed-methods design. Qualitative data were sourced from VIHSP publications, internal protocols and presentations, and from study-designed questions completed by senior VIHSP staff. Qualitative data were summarised using textual analysis to describe current functioning and to compare VIHSP with other UNHS programs in Australia and New Zealand. Quantitative data were sourced from the VIHSP clinical database and included a retrospective review of infants born 1st January 2012 to 31st December 2020. Quantitative analysis described: screening coverage; screen refer rate; the positive predictive value (PPV) of the screen; proportion of referred babies acknowledged by the VIHSP Early Support Service (ESS) within three business days; proportion of babies who commenced diagnostic audiology by three months corrected age; and age at diagnosis, early intervention, and amplification.
Results Contextual analysis from qualitative data indicated that in 2005, universal screening commenced in maternity hospitals with tertiary neonatal services, screening well babies and babies in the neonatal intensive care unit/special care nursery. State-wide rollout was completed by 2012, with VIHSP providing universal newborn hearing screening to approximately 80,000 births annually, using a two-stage automated ABR protocol. VIHSP today is characterised by a sophisticated information system, comprehensive documentation and reporting which is continuously reviewed and updated, accessible professional development for all staff, ongoing training and competency assessments; ongoing quality improvement relating to clinical data collection; and stakeholder engagement with diagnostic audiologists, early intervention and amplification services.
Quantitative analysis indicated that in Victoria, 699,915 babies were screened between 2012 and 2020, with consistently high coverage for newborn hearing screening, averaging 99.5%. The overall screen referral rate was under 1% (benchmark <4%). Overall, 97.8% of babies referred to ESS were acknowledged within three business days (benchmark >90%). The positive predictive value of a VIHSP positive screen result is 9.8%, and the prevalence of target hearing loss was within the expected range. From 2014 onwards, the proportion of babies whose diagnostic audiology assessment commenced by three months corrected age was between 93% and 97%, (benchmark >90%). For infants born in 2020, the median corrected age, in months, at the time of diagnosis, enrolment into early intervention, hearing aid fitting, and cochlear implant surgery was 0.5, 0.9, 1.8, and 8.3 months, respectively.
Comparison between VIHSP and other UNHS programs within Australia and New Zealand revealed the predominant use of automated ABR screening technology, using either a two- or three- stage screening protocol. In addition, each UNHS program defines the target condition they screen for differently, in regard to type and degree of hearing loss.

Conclusion VIHSP uses a two-stage automated ABR screening protocol with high coverage, and an acceptable positive predictive value (for detection of the target condition). VIHSP performance has steadily improved since state-wide rollout and has met all internal and best practice guidelines. This has been possible due to the structure, activities, and resources available to families, VIHSP staff, and stakeholders. While some similarities are evident between VIHSP and other Australian and NZ UNHS programs, more information about the functioning, structure and governance of these programs would be helpful for comparison and transparency. Overall, VIHSP is consistently exceeding best practice guidelines in the early detection of infants born with PCHI.

IMPROVING HEARING CARE AND SERVICES (1)

391 - Hear@work: barriers, facilitators, and opportunities to support employees with hearing loss
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Background and objective: As retirement age is being pushed back, the number of people with hearing loss in the workplace will increase. The workplace is a challenging situation in which it is critical to hear well for optimal performance. Hearing solutions and accommodations are underutilized and access to adequate support and care is suboptimal for those with hearing loss in the workplace. Improving support for employees with hearing loss could empower them to manage their hearing loss at work and to remain productive. In this project, we explored the perspectives of Dutch employees who have hearing loss and those of Human Resource (HR) advisors on the current practices and opportunities to improve support for employees with hearing loss.
Design: Online text-based focus group with employees with hearing loss and online interviews with HR advisors representing different company types. The focus group and interview data were thematically analyzed.
Results: For employees with hearing loss, disclosure, expressing one's needs and autonomy at work were important personal facilitators. Environmental barriers included employers' lack of knowledge about consequences of hearing loss in the workplace, fragmentation of information provision, and dissatisfaction with occupational support and support from hearing professionals. Support needs were identified in the (better) access to knowledge, practical and emotional support, and referral routes for adequate care. Access would be enabled if there was one central information point. HR advisors reported a lack of knowledge about problems experienced by employees with hearing loss. Also, unfamiliarity with organizational policies concerning hearing difficulties in the workplace was seen as a barrier to giving adequate support. The support needs included having (better) access to adequate information and the policy guidelines.
Conclusions: Both employees and HR advisors require better access to knowledge, and guidance from health care and services relevant for functioning with hearing loss at work. The findings have informed on the development of an online platform, to improve access to relevant information, thereby facilitating support for employees with hearing loss and their employers.
Acknowledgement *This work results from a collaboration between VUmc and Sonova Netherlands B.V. The collaboration project is co-funded by the PPP Allowance made available by Health~Holland Top Sector Life Sciences & Health (https://www.health-holland.com) to stimulate public-private partnerships.*

174 - Triage for adults: What tools do Audiologists need for the future?
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Background There are currently at least half a billion people in the world with hearing loss who would benefit from intervention. With it's links to social isolation, falls; and hearing loss being cited as the biggest modifiable risk factor for prevention of dementia, looking after your hearing has never been more important. The first steps in doing that is for people to understand their hearing needs (and why!).

With the burden of disease growing globally, the role of the audiologist & ENT clinicians will need to evolve to ensure that the demand can be met and good evidence based patient centred interventions can be offered, and used. Innovation and a change in the hearing care pathway is the only way this can be done. The TympaHealth system from the NHS England Clincal Entrepreneur Program could be a part of that 'digital patient pathway' revolution/solution. It enables allied health professionals to deliver digital otoscopy and ear wax removal through micro-suction and hearing screening all via one m-health tool. This tool will then enable the audiologist to deliver efficient best practice patient centred care to patients with genuine need once triaged.
Methods We report here a pilot trial of The Tympa System in 100 UK high street locations within the Boots Hearingcare network, which routinely provides hearing health services. Hearing Health-Care Assistants were trained to ENT UK & BSHAA standards to deliver otoscopy and ear wax removal with the Tympa System. They were observed and signed off by a mentor before practicing independently.
Results Over a 1-year period 10786 patients enquiring about hearing care in the stores were seen. There was an incidence rate of 1.9% of concerns over the device use. This was mainly due to software issues that were immediately resolved. Only 2 patients had to be referred to / escalated to ENT. These were both discharged after clinical exam on arrival. This highlights the safety and efficacy of the procedure when operated by a trained individual.
Conclusion This device has enabled the hearing care pathway to be changed and delivered safely and under the guidance of ENT surgeons and Audiologists. With the portability of the device there is huge potential for community-based services especially in low resource countries and through delivery and triage by trained allied health professionals the ability to cope with increased referral rates as countries start to tackle the increased burden of hearing loss.

429 - Development of an outcome measure for empowerment in adults with hearing loss

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Introduction Over the last few years, the concept of empowerment has emerged from studies of mhealth technologies, such as smartphone-connected hearing aids and multimedia educational resources for hearing aid users. However, there is currently no hearing-related measure of empowerment. Objectives of this research were to (i) conceptualise empowerment along the hearing patient journey, to then inform (ii) the development of an outcome measure of empowerment for adults with hearing loss.
Design A semi-structured interview study was conducted in adult hearing aid users from Australia (n=10) and Sweden (n=8) who had worn hearing aids for between 6 to 36 months. A thematic template analysis was used, based on Zimmerman's theory of Empowerment. The results generated content for the development of an outcome measure of empowerment, based on best practice COSMIN guidelines. The relevance and clarity of the measure was evaluated through (i) cognitive interviews with a total of 16 adults with hearing loss (n=8 for both Australia and Denmark), and (ii) an expert panel of audiologists and researchers, initially in Sweden and then in Australia. The items are currently undergoing refinement and their psychometric properties identified by applying modern psychometric analysis, namely Rasch analysis, and traditional analysis from more than 352 adults with hearing loss.
Results The thematic dimensions that emerged from the interview study were knowledge, skills and strategies, participation, self-efficacy, and control of their hearing health care, hearing solutions and everyday lives. A pool of 38 items were initially generated across the five themes of empowerment. Following refinement resulting from 16 sets of cognitive interviews from Swedish hearing aid users and an expert panel of hearing healthcare professionals, the final pool of items was 37. Relevance and clarity from the initial Swedish sample were 3.57 and 2.94 respectively (range 1=low, 4=high). The items underwent further refinement with 8 Australian hearing aid users and an expert panel resulting in a pool of 33 items. Relevance and clarity increased to 3.96 and 3.70 respectively. Ongoing psychometric analysis will identify whether or not the measure is uni-or multi-dimensional following removal of items with unfavourable properties, such as poor fit or redundancy. Reliability and validity will be established.
Conclusions The resulting outcome measure, following psychometric analysis, will enable measurement of the concept of hearing-related empowerment prior to, and following a hearing intervention, for example hearing aids.

323 - Effectiveness of TympaHealth in shortening waiting time for wax removal

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Introduction Wax accumulation is an important cause of hearing loss which can be easily addressed to provide a positive impact on patients' quality of life. The patient referral pathway in the National Health Service (NHS) in the UK for wax removal can be convoluted. Referrals for hearing aid fitting for presbycusis can be delayed due to impacted wax. Novel devices for visualisation and wax removal are therefore much-needed. TympaHealth is a new and innovative device designed to be an all-in-one hearing health assessment system capturing high-quality images and video clips, wax removal and a screening hearing assessment.
Methods The use of the TympaHealth device was trialled in a busy London hospital from July to September 2020 in a prospective study of 21 patients. Audiologists underwent training to use the device. The primary outcome measure was length of time from referral to wax removal using TympaHealth device versus non-TympaHealth device e.g. microscope. Secondary outcome measures were patient satisfaction, ease of use by clinicians and effectiveness of wax removal.
Results Average patient age was 71 years old with a male:female ratio of 7:12. The mean length of time from August 2019 to April 2020 from referral to wax removal was over 270 days, whereas when using the TympaHealth device, the mean length of time was 0.76 days. There was a statistically significant reduction in waiting time using the TympaHealth device compared to conventional method ($p = <0.001$).
In 86% of cases, clinicians were able to completely remove the wax; in the remaining, referral to ENT was necessary. 100% of the patients would have the procedure again in the future if required.
Conclusion The TympaHealth device is an effective tool for wax removal which has been shown to be easily used by non-ENT clinicians and has reduced the patient referral pathway time, resulting in patients then undergoing audiometric testing and hearing aid fitting without delay.

96 - Etiology, medical comorbidities and health service use of children with permanent hearing loss

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Early detection of hearing loss has allowed hearing impaired children early access to hearing amplification, early intervention and cochlear implantation where appropriate. Understanding predictors of health service use could optimize service planning for these families, and direct policy development. We aimed to document etiology, pattern of hearing loss, medical comorbities, and health service use in a clinical cohort of hearing impaired children.
We report on the results of a clinical audit of the first 535 children attending the Caring for Hearing Impaired Children (CHIC) Clinic, a tertiary outpatient clinic at the Royal Children's Hospital Melbourne, Australia, from February 2016 to December 2019. The CHIC clinic offers paediatric medical and developmental assessment and management of hearing-impaired children aged 0 to 18 years in the state of Victoria, Australia. We examined the electronic medical records to determine the etiology and pattern of hearing loss, relevant medical history, physical examination findings, investigations and health service use. Hearing loss was categorised as unilateral or bilateral, and mild, moderate, severe and profound. Medical history included family, antenatal, birth/perinatal, postnatal history and comorbidities (defined as other medical conditions related to the hearing loss). Physical examination included dysmorphology, ear abnormalities, middle ear effusions, abnormal neurological findings and hepatosplenomegaly. Investigations included imaging (magnetic resonance imaging, computed tomography, ultrasound), genetic testing (connexin, microarray, whole exome sequencing), other blood tests and electrocardiogram (ECG). Health service use was assessed, including department encounters, referrals, and early intervention.
Our audit will describe the health service use of children with all degrees and types of hearing loss in relation to the underlying etiologies and medical comorbidities. The results will have implications for health service policy for children with hearing loss.

112 - Empowering Managers to change workplace culture for greater collaboration with maternity hospitals

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A successful partnership arrangement between Victorian Infant Hearing Screening Program (VIHSP) and maternity hospitals has been the foundation of a family-centred and reliable hearing screening service over the past 11 years. Moving forward, a stronger collaborative culture between the VIHSP Area Managers (AMs) and maternity hospitals is fundamental to the continued success of newborn hearing screening in Victoria.
VIHSP AMs have been working to strengthen relationships for efficient and productive task completion, working closely with local maternity hospital staff. To best equip the AM group to undertake this task, VIHSP empowered this team in three ways. First, an education phase was undertaken by all AMs with individual completion of a Diploma of Leadership and Management which included a strong emphasis on change management. Second, tools were supplied to enable the AMs to educate hospital teams on hearing screening. Finally, local reporting was introduced.
Authored by the AMs, this local report measures the completion of key tasks across managed hospitals. Tasks include OH&S assessment, and development of staff and stakeholder engagement events and strategies. Stakeholder information is documented by the AMs and shared with their Senior Managers on a monthly basis, creating a current and accurate database of key hospital contacts. For the first time stakeholder engagements are measured against benchmarks resulting in increased stakeholder contact. Increasing collaboration between AMs and local maternity hospital staff affords greater opportunities for improved forward planning. Review of improvements continues.

101 - Severe and profound hearing loss in adults: What is best practice?

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When it comes to adults with severe and profound hearing loss, audiological management often fails to produce the outcomes which the client hopes for and the clinician expects. A new international project has just completed and published a review the scientific literature around the topic of severe and profound hearing loss and amplification. Participants in the project are recognized experts in clinical audiology. The project has identified specific actions which audiologists can implement to improve outcomes for adults with severe and profound hearing loss. Some findings and recommendations for practice will be outlined.
Adults with severe and profound hearing loss present us with many challenges in the audiology clinic. Sometimes the results of amplification, even when accepted practice for those with mild to moderate hearing loss, fails to meet the needs of adults with severe and profound hearing loss. For example, a manufacturer proprietary fitting rationale may deliver comfort and sufficient audibility to achieve immediate acceptance by a new hearing aid user, but may under-fit a severe and profound hearing loss. There is a need to understand best practices for severe and profound hearing loss and identify some directions for future research.
Evidence based practice is fundamental to best practice, however, the results of the project have highlighted the paucity of high-quality evidence available to those audiologists who work with adults with severe and profound hearing loss. The scientific literature offers weak evidence for the audiological care of these adults especially those who continue to rely on conventional amplification. In the absence of evidence, expert recommendations are offered. The project has identified specific actions which audiologists can implement to improve outcomes for adults with severe and profound hearing loss.
This paper will highlight some examples of the special considerations and practices required to optimize the outcomes for adults with severe and profound hearing loss and their communication partners. Specific topics include, assessment, amplification with hearing aids and other devices, remote microphone technologies, safety and warning devices, considerations for communication partners, tinnitus and referral for implantable devices.
The project has concluded following the publication of guidelines. Some key recommendations will be presented. These will inform best practices specific to the audiologic management of adults with severe and profound hearing loss with conventional amplification. These findings can be implemented immediately by audiologists who care for these adults.

142 - Comparison smartphone enabled video otoscope, surgical loupes and microscope for novices learning aural microsuction – is this the future for Audiologists and allied health professionals.
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Background Traditionally ear wax removal has been managed with ear syringing. NICE guidelines advise against this and advocate other techniques including microsuction. A smartphone enabled video otoscope (Tympa system) has been developed to facilitate aural microsuction. In this study we assess its applicability for novices to perform ear examination and aural microsuction compared to microscope and loupes.
Methods 29 medical students undertook a pre-study questionnaire investigating their knowledge, confidence and experience of techniques for otoscopy and aural microsuction. Participants underwent standardised teaching on anatomy and microsuction technique using the Tympa system, clinical microscope and surgical loupes. Participants were asked to rate their confidence and preference with using each modality using a Likert-like questionnaire.
Results Mean confidence of ear examination prior to intervention with use of Tympa vs microscopes vs surgical loupes was 1.24 vs 1.52 vs 1.13 (1= least, 5 = most). After teaching, all modalities demonstrated a significant increase in confidence in ear examination ($p<0.0001$). However, the median of differences in confidence for Tympa vs microscopes vs surgical loupes was 1 vs 0.66 vs 0.75. Tympa was the preferred method in all other parameters assessed including: learning anatomy/pathology (62.1%) and learning microsuction (65.5%).
Conclusions Ear examination and microsuction is currently best provided with microscope and endoscope techniques. Both these modalities have significant cost and training investments required. Smartphone technology is used in everyday life and is being utilised in medical devices as it is easily adoptable. The Tympa system provides an alternative modality for the non-specialist to perform ear examination and aural microsuction. This will aid specifically Audiologists in providing a more comprehensive service and have a role in screening.

Technology Update

213 - Tasks and duties of a Tracking Center in screening programs
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Early Hearing Detection & Intervention (EHDI) approaches in Newborn Hearing Screening give a clear demand for a centralized data collection and systematic tracking of babies. Evidence-based data clearly reveals the weaknesses in the programme and improves the cost-effectiveness and sustainability of a screening system. The main tasks of a Tracking Center is to follow-up babies, either without screening or with the need for further examination. This is usually done by staff who are working in a Tracking Center and using a tracking software system. Parents or caregivers will be contacted by tracking staff and convinced to attend a follow up as long as a diagnosis has been confirmed. Ideally, demographic- and test data will be gathered and transmitted directly from the test-instruments. This is to minimize data loss by entering data in several systems or a risk of data modifying by the examiner.
Nevertheless, a number of communication channels are needed to collect information including updates from screening and follow up sites as well as from parents or further medical institutions.
Within the daily routine a Tracking Center has to fulfil more services. The malfunction of one individual process in the system will significantly influence the outcome or could lead to a delay in diagnosis for the patient. Data needs to be maintained. Double entries and data inconsistencies need to be identified and corrected. Resubmission dates in the database as well as appointments on follow up sites need to be monitored. Reminders need to be sent out to parents and caregivers.
A Tracking Center is also supposed to observe the quality of a screening program. A decreasing quality of screening tests affects the number of children to be re-tested. Furthermore, this affects the availability of appointments and finally the age of diagnosis for babies with a hearing disorder.

The presentation will illustrate how diverse the influences can be, that can lead to a delay in the diagnosis age. Quality control has a significant influence on the diagnostic age of babies with a hearing disorder. The presentation is based on the experience of implementing a quality-controlled hearing screening program in more than 10 countries and regions with more than 5 million children tested. It will be shown that regional differences have less influence on the outcome of the program than continuous quality control.
Keywords: Tracking, Newborn Hearing Screening, Tracking Software, Tracking Database

445 - Recording Otoacoustic Emissions (OAE) with Adaptive Noise Cancellation (ANC)
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Otoacoustic emissions (OAEs) are low-level sounds of cochlear origin, which can be recorded by a sensitive microphone fitted into the ear canal. Preferably, OAE measurements are conducted in a clinical environment under controlled noise conditions like acoustically shielded sound suites. However, in environments with higher ambient noise levels, measurements are challenging since ambient noise that travels past the seal of the ear tip can hinder detection of OAEs.
To compensate for this we have designed an ear probe with two microphones, one located at the back for capturing ambient noise and the other (primary microphone) for capturing the OAE response in the ear canal. The adaptive noise cancelling system maintains an adaptive digital filter which the outer microphone's signal is processed with and then subtracted from the inner microphone's signal. This can remove a significant portion of noise from the recorded signal without influencing the OAE response. First OAE measurements with our QSCREEN hearing screener show that the ANC technique speeds up testing in noisy surroundings by up to 90 %, corresponding to a noise reduction by up to 10 dB.
Keywords: DPOAE, TEOAE, OAE, Adaptive Noise Cancellation (ANC)

427 - New telematic and telemedical options in newborn hearing screening
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Newborn hearing screening is typically understood to consist of using an objective screening test within the first few days of a newborn's life to enable the diagnosis of hearing impairment at a younger age.
But where test results require follow-up, most screening projects should require the child and their parents/carers to attend a specialist clinic for medical follow-up as soon as possible.
Hearing Screening Centers (HSCs or "tracking centres") coordinate the exchange of such information between maternity facilities, parents/carers and follow-up specialists. HSCs are therefore, in reality, quite complex telematic projects requiring considerable work by staff for data and quality management.
This talk is about a system for the automated bidirectional transmission of hearing screening data based on mobile communication technology for different screening devices (Madson Accuscreen, Natus Accuscreen/EchoScreen II and Sentiero Advanced from Path Medical). This technology is used to overcome some issues with high on-site support (e.g. dependence on the IT infrastructure of the hospital and configuration of screening devices after maintenance) and enables the addition of telematic options to deal with the challenges facing screening and tracking.
In countries with non-comprehensive audiological expertise, an extended hearing screening test with diagnostic elements can be performed directly in the maternity clinic under external audiological supervision.
This solution can easily be integrated into the tracking software used in tracking centers in combination with device configuration software and data integration software for sending, receiving and exporting data. This transmission technology is currently being used in hearing screening projects in Germany, Iran, Brazil, Kazakhstan, Uzbekistan and the Ivory Coast.
Finally, some interface problems faced by federally organized screening programs are addressed: comparing parameters for quality management with the help of a multicentric online benchmarking system for maternity facilities; and a concept for tracking across project and state/country borders.

IMPROVING HEARING CARE AND SERVICES (2)

499 - Bone conduction devices and long-term follow-up of the Bone Conduction Implant

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Background Bone conduction hearing is when vibrations in the skull bone are led to the inner ears and create a hearing sensation, and it is used in several applications. One of the most important for hearing rehabilitation, where bone conduction devices (BCDs) are especially suited for patients with conductive and mixed hearing loss, but also for single sided deaf patients. The percutaneous bone anchored hearing aid (BAHA), attached with a skin-penetrating implant in the bone behind the ear, which is considered the golden standard in the field of BCDs, was first developed over 40 years ago and has been implanted in more than 300 000 patients worldwide. Now, several transcutaneous alternatives, where the skin is intact, have been developed. These provides either vibrations through the skin or uses an inductive link to transmit the sound energy through the skin to an implanted transducer for direct stimulation in the bone. One of the alternatives for direct bone conduction is the Bone Conduction Implant (BCI), which has been developed by research collaboration at Chalmers University of Technology and Sahlgrenska Academy in Gothenburg, Sweden. The BCI consists of an external sound processor, attached with a magnet, and an implant with the transducer in a small recess in the skull bone. The BCI is in a clinical study and 16 patients have received the implant. In this presentation, a review of today's BCDs will be shown, as well as the latest results from the BCI.
Methods The BCI patients are followed regularly with audiometric tests, questionnaires, and objective measurements. Before the surgery, they used a BAHA on a softband as a reference device for four weeks and were examined with the same tests as later for the BCI. At the time of the HeAL conference, all patients will have passed the last follow-up visit of 5 years after fitting the device.
Results and discussion The accumulated time with the implant is now more than 108 years, and there has been no serious adverse event in this time. The audiometric tests and questionnaires show statistically significant improvement over unaided situation, and similar or better results with the BCI compared to the reference device. The objective measurements have shown stable transmission of the device over time, and that the retention force increased in the initial stage of the study but stabilized over time.
Conclusions It was found that the BCI can give effective and safe hearing rehabilitation for patients with conductive and mild-to-moderate mixed hearing loss. In a comparison with other transcutaneous devices with direct bone stimulation, similar results were seen.
Keywords Bone conduction, Bone conduction devices, hearing implant, BCI

500 - A cross-sectional survey of contemporary Australian audio-vestibular clinical practice for traumatic brain injury and rehabilitation

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Objective: This study explored contemporary audiological clinical practice in the context of TBI, and whether such practices incorporated considerations of TBI related complexities pertaining to identification, diagnosis, and management of associated auditory and vestibular disturbances.
Design: A cross-sectional online survey exploring clinical practice, TBI related training, and information provision was distributed to audiologists across Australia via Audiology Australia and social media. Fifty audiologists, 80% female and 20% male, participated in this study. Years of professional practice ranged from new graduate to more than 20 years of experience.
Results**:** Clear gaps of accuracy in knowledge and practice across all survey domains relating to the identification, diagnosis, and management of patients with auditory and/or vestibular deficits following TBI were evident.
Conclusion**:** Inadequate resources, equipment availability and TBI related training may have contributed to the gaps in service provision, influencing audiological management of patients with TBI. A tailored TBI approach to identification, diagnosis and management of post-traumatic auditory and vestibular disturbances is needed.
Keywords: post traumatic auditory and vestibular dysfunction, TBI, audiological clinical practice, Australia

502 - 'Nobody has a caseload called, Patients with Traumatic Brain Injury': Australian audiology educators' perspectives on including traumatic brain injury in the curriculum

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Objective: This study examined what traumatic brain injury (TBI) related curriculum is included in Australian graduate audiology programs by interviewing leading academic educators.
Design: A qualitative research design employing semi-structured interviews was conducted. A total of six leading academic educators from all six Australian graduate audiology programs participated in the study. Interview transcripts were analysed using thematic analysis.
Results: Implementation of TBI content into audiological curricula was found to be influenced by three interrelated themes: professional culture, contextual barriers, and practice of teaching and learning.
Conclusion: The findings provide an insight into the perceived barriers associated with incorporating TBI related content into existing audiology curricula. The findings further emphasize the importance and need to strengthen audiology curricula in the context of TBI to support graduate audiologists in delivering high-quality care and management to patients with post traumatic audio-vestibular disturbances.
Keywords: TBI: medical audiology, TBI related curriculum, student readiness for practice

e- AND m-HEALTH SOLUTIONS, COMPUTATIONAL AUDIOLOGY

275 - Computational Audiology: new ways to address the global burden of hearing loss
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Background Hearing loss can be considered the most prevalent health impairment worldwide, with adequate diagnosis and treatment lacking for most. Computational audiology, the augmentation of traditional hearing health care by digital methods, has potential to dramatically advance audiological precision and efficiency to address the global burden of hearing loss.
Advances Modern machine learning and data collection techniques combined with mobile technology will transform hearing health care. Quantifiable aspects of audiology make it well suited for computational augmentation, automation and clinical decision support. These advances can improve access to care, personalize diagnoses and treatments, and lead to better quality services. Here, we will present recent examples that illustrate the potential of computational audiology and raise awareness for risks associated with big-data processing and emerging medical artificial intelligence (AI) applications.
Outlook Computational audiology can be applied along the entire spectrum of hearing health care: from fundamental auditory science to more clinical and translational work on diagnosis, treatment, and rehabilitation across the lifespan. Computational assistance can replace some of the tasks currently performed by experts, reduce testing burdens and, most importantly, improve access, quality, and uniformity of hearing health care on a global scale. Computational audiology may initially serve as an assistive tool in the hands of the expert but we foresee that modern mobile phones, readily available in billions of pockets across the world, will catalyze the democratization of audiology. However, a potential risk of highly autonomous and self-learning clinical decision support systems is that, depending on the design, they behave like black boxes. Such systems are not interpretable and unsuitable for an informed-decision process. Also, it hinders independent inspection, collaborative research, and awareness for biases in data. In order to accomplish a fair, affordable, and safe digital transformation of audiology, we must join forces with experts in computational sciences, agree on global standards and evidence-based procedures, and carefully consider the possible challenges and risks of big data and AI technology.

293 - A framework of explainable artificial intelligence for adult hearing screening
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Background: Recently, a novel speech-in-noise test for adult hearing screening integrated with multivariate logistic regression, involving a certain number of features besides the speech-recognition-threshold (SRT) (i.e., the usual output of speech-in-noise test) has proven to be as accurate as comparable state of the art hearing screening tools. Despite its prevalence, hearing loss is often neglected, especially by older adults that are reluctant to test their hearing abilities. Even more so, these subjects may not fully trust recommendations/predictions provided by a new hearing screening tool, if its decision-making process is based on 'black box' models, thus lacking of transparency. Therefore, the integration of the previously mentioned speech-in-noise test with eXplainable Artificial intelligence (XAI) models, supplied with a set of intelligible rules and numerical cut-offs, may provide reliable advices about the subject's hearing condition.
Methods: A trustworthy screening platform based on a natively explainable algorithm called Logic Learning Machine (LLM) was implemented. The classification task was performed and evaluated starting from nine features related to hearing screening data collected from 148 subjects. Generative Adversarial Networks were used to create synthetic augmented datasets with 1000 records. The quality of two synthetic datasets with slightly different Maximum Mean Discrepancy (MMD) values was evaluated in terms of generated rules (defined by cut-offs, number, covering end error) and related classification performances on real and augmented data. Specifically, the synthetic datasets were evaluated in terms of classification performance on three different conditions besides the real performance (A): LLM trained and tested on synthetic data (B), LLM trained on synthetic data and tested on real data (C), LLM trained on real data and tested on synthetic data (D).
Results: The real classification performance was evaluated on ten randomly shuffled versions of the training and test set (average F-measure (A): 74%; average n° of rules: 10; average n° of conditions per rule: 2.5; average covering: 37.1%; average error: 3.22%). The LLM led to stable single-condition rules among ten iterations in the form $age \leq \mu_{age}$ for the *'pass'* class and $\#correct \leq \mu_{correct}$ for the *'fail'* class. More complex rules involving the same parameters were often coupled with additional conditions involving for example SRT, the percentage correct responses and the average reaction time. Features like the volume and the total test time showed instead a lower relevance, hence being only sporadically involved as rules conditions.
The F-measure was evaluated in three conditions for both the synthetic dataset, respectively, the high MMD one (B: 50,3%; C: 67,8%; D: 56,54%) and the low MMD one (B: 95,13%; C: 74,3%; D: 70,6%).
The dataset with higher MMD (i.e., lower quality) showed rules with less similarities as it was characterized by a higher average number of conditions and rules that didn't reflect the real relationships between input features and the output class. On the contrary, the synthetic dataset with lower MMD (i.e., better quality) showed better classification performance on both synthetic and real data, thanks to a set of representative rules.
Conclusion: The use of speech-in-noise tests coupled with multivariate explainable techniques may allow trustworthy and accurate online hearing loss detection. Nevertheless, AI methods require a large amount of data in order to guarantee a more than satisfactory performance. Data scarcity in the medical field can be tackled with the use of data augmentation. However, synthetic data must guarantee a faithful reproduction of the real phenomenon observed. There appears to be some agreement between traditional metrics for data quality assessment and parameters derived from the classification performance on both the synthetic data itself and the real data. The use of XAI allows additional information to be extracted with respect to validation of the extracted rules. Ongoing research is focusing on the creation of a synthetic data quality metrics based on the combination of classification performance (i.e., covering, error, n° of conditions per rule) and a measure of similarity between rules derived from the synthetic dataset with respect to those derived from the real dataset.
Acknowledgement: The work leading to the creation of the dataset used in this study was partially supported by the Capita Foundation through project WHISPER, Widespread Hearing Impairment Screening and PrEvention of Risk (2020 Auditory Research Grant).
Keywords*:* hearing screening, explainable AI, speech-in-noise test, speech-recognition threshold, mild hearing loss

155 - Data changes everything: Insights and lesson from large m-health audiometry datasets

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Outcome Objectives:

1) Acquire actionable practice changing insights from novel data sets
2) Recognize the importance and utility of data in hearing sciences
3) Demonstrate an understanding of common missteps in data aggregation and analysis

Background: New digital testing platforms have enabled the aggregation of a large set of audiograms, opening a "cautious" window of possibility regarding new insights surrounding hearing loss. This session will be comprised of a discussion of the successes and problems encountered with both large and small datasets. Current gaps will be highlighted in the data-driven understanding of prevalence, natural history, and outcomes. Further, we aim to share strategies to assist others in the study design and interpretation of Big-Data, as well as present the key finding from our aggregated data-set.

Massive data sets that are aggregated through electronic health records, online tools and wearables will change practice decision making within otolaryngology. These tools need to be examined, understood and used to protect our patients.

Methods: A large aggregated dataset was limited to those aged 20+ years with valid thresholds at 500, 1000, 2000, 4000 and 8000 Hz on both the left and right ears. Results were compared to published values to determine how comparable the data is to known prevalence of hearing loss. Areas of improvement for future data aggregation, the importance and value of this type of data for clinical practice is also discussed.

Results: Results from 63,625 audiograms indicate slightly lower (better) hearing thresholds compared to published presbycusis curves and results from a published population study. The results emphasize the importance of understanding the data contributing to the sample impacting generalizability of data.

In order for data from multiple sources to be combined into a single larger dataset there needs to be standardized input parameters with detailed information on the test protocol (e.g., transducer model captured, frequencies tested, audiometer used). For the data analysis, particular attention must be paid to the question (i.e., does the current data contain the information required to evaluate the hypothesis). Statistical significance must not be confused with clinical significance when analyzing large datasets.

Limitations to 'open source' data aggregation include unknown quality of manually entered data limiting the generalizability and strength of conclusion that can be drawn.

Comment: Big-Data could be the single largest factor to transform the future of healthcare, yet it is largely misunderstood and left in the hands of computer scientists. For data to drive our clinical decisions, the right questions need to be asked, framed and interpreted by physician researchers. It is essential to engage and lead the coming transformation by highlighting data as the future of medicine.

REMOTE CARE, e- and m-HEALTH SOLUTIONS (1)

183 - Teleaudiology Hearing Aid Services with Community Health Workers as Patient-Site Facilitators: A Feasibility Evaluation Using the RE-AIM Framework

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Introduction: Globally, an estimated 466 million adults (5 % of the world's population) have disabling hearing loss (WHO 2018). However, the majority of individuals with hearing loss do not have access to hearing health care professionals (Swanepoel et al., 2010). Teleaudiology helps improve audiologists' reach to patients in rural and underserved areas. In addition, recent research has highlighted the innovative use of Community Health Worker-based programs to improve access to hearing health care (O'Donovan et al., 2019), including with teleaudiology (Yousuf Hussein et al., 2018). The contribution of the current work is to develop and the feasibility of Community Health Worker (CHW) facilitators in teleaudiology hearing aid fittings for older adults with hearing loss within the RE-AIM feasibility evaluation framework (reach, effectiveness, adoption, implementation, maintenance). Methods: Adults (ages 50+) with bilateral hearing loss in a US/Mexico border community in Arizona were eligible to participate in this study. Individuals were randomized to one of two teleaudiology intervention arms that differed at the level of the patient-site facilitator: CHW or university student (control). Synchronous teleaudiology hearing aid services took place with participants located at a local community health center and the clinician located at a university 70 miles (112 km) away. Feasibility was assessed by analyzing the five dimensions of the RE-AIM framework using quantitative and qualitative data. Reach was measured by examining the overall number and representativeness of individuals who were screened and enrolled in the intervention. Effectiveness was evaluated by the primary outcome, communication self-efficacy, measured by the Self-Efficacy for Situational Communication Management Questionnaire (SESMQ) and hours of hearing aid use (datalogging). Qualitative interviews were used as

indicators of adoption. Video-recordings of sessions were analyzed to evaluate implementation fidelity, and maintenance was evaluated by observing long-term (17 weeks post hearing aid fitting) outcomes.
Results: *Reach*: CHWs recruited 57 individuals, 47 were consented, and 28 were enrolled. Approximately forty percent (n = 19) did not meet study inclusion criteria, mainly because their hearing thresholds were measured at < 25 dB HL. Participants' average age was 73.9 years (range: 55 to 89 years), and all reported their ethnicity as Hispanic/Latino. Most individuals (75%) were female, and most (86%) reported an annual income of less than $20,000USD. *Effectiveness and Maintenance*: Both groups (CHW and control) significantly improved communication self-efficacy (SESMQ) from pre-fitting baseline to 2-weeks post-fitting, and benefit was maintained over time (to 17 weeks), but no significant difference between groups was observed. Regarding datalogging, at 2-weeks post-fitting, the CHW group wore their hearing aids for more hours than the control group. *Adoption*: A total of 19 qualitative interviews were analyzed. Results revealed that CHW group participants recalled the facilitator engaging in patient-centered care (i.e., asking them questions, making them feel comfortable), while control group participants recalled procedural aspects of the hearing aid fittings. *Implementation*: Fourteen video-recordings were available for analysis. Results revealed that the protocol was delivered as intended, with the exception of two control group recordings that did not capture video otoscopy. *Maintenance*: Long-term maintenance of CHW-supported teleaudiology could be feasible with institutional infrastructure, ongoing trainings, and funding measures to support hearing aids and services
Conclusion: Teleaudiology-delivered hearing aid services were feasible when facilitated locally by trained Community Health Workers. Teleaudiology will be crucial to help address disparities in hearing health care. Future effectiveness trials are warranted, potentially leading to a significant improvement in access to hearing care for rural and medically under-resourced communities.
Discussion: Research has previously demonstrated that teleaudiology has the potential to improve access to hearing health care for rural and underserved communities. This study illustrated the feasibility of Community Health Workers in one community to collaborate with audiologists in teleaudiology service delivery and increase access to care in a rural and under-served area. Future studies expanding on this research may include partnering with Community Health Workers to conduct teleaudiology-delivered hearing aid services in other communities.

113 - Barriers, acceptability and uptake of an internet-delivered UK adult hearing check

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Hearing loss is is ranked 5th for burden of disability and untreated hearing loss cost the UK economy approximately £25 billion in 2013. Around 14% of UK adults aged 55-74 years have a hearing loss >35 dB HL but only 3% use a hearing aid. Among hearing aids users, the average delay before seeking help is 15 years, further increasing the years lived with disability. A systematic adult hearing screening program may reduce burden of hearing loss by increasing rates of hearing aid use, and promoting use at an earlier age. The study is an evaluation of an internet-based systematic hearing screening delivered via primary care practice.
1300 individuals aged 50-75 years randomly selected from one primary care practice received an invitation from their doctor to complete a brief online hearing check. A subset were asked to complete a questionnaire about barriers to completing the online hearing check based on the capability, opportunity, motivation-behaviour model as well as the acceptability of the check. The aims were to i) estimate the proportion of adults aged 50 to 75 years completing an internet-delivered hearing screen, ii) estimate the proportion who complete the internet-delivered screen who have a hearing loss, iii) identify barriers that may prevent individuals from completing an internet-delivered hearing screen and iv) collect feedback about the acceptability of the internet-delivered hearing screen.
10.4% of people took up the offer of a hearing check. Of those who took the check, 75% failed the check (indicating a likely hearing loss of >35 dB HL). There were no differences in ethnic background, gender, ethnic background, or number of GP consultations in the past year between those who took the hearing check and those who did not. Those from less affluent socioeconomic backgrounds were less likely to take the check compared to those from more affluent backgrounds. Few barriers to online hearing screening were reported, and online hearing screening was acceptable to most respondents.

Online hearing screening offered via primary care offers an effective and acceptable paradigm for systematic adult hearing screening. Further attention could be devoted to understanding and addressing barriers to uptake of hearing screening among those from lower socioeconomic backgrounds.
Key words: Early Identification of Hearing Loss (screening and diagnosis), e-Health and m-Health

411 - Introducing remote models of care into the Cochlear Implant service: The clinician and user experience

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Introduction: University Hospitals Birmingham (UHB) is one of the largest NHS teaching trusts in England treating over 2.2 million people per year. The Cochlear Implant (CI) service actively manages over 1300 existing patients and on implants around 110 new patients each year. Growth predictions for the CI market are high with the global CI market expected to grow at a compound growth rate of 10.5% (Grand view research 2020). Predictions for UK growth are equally high; by 2035 over 15 million people will live with disabling hearing loss, more than 900,000 of these will suffer severe to profound hearing loss (Action on Hearing Loss 2015) and recent changes in criteria (NICE 2019) for CI's have increased eligibility for many patients who previously failed to meet the criteria for implantation. The increase in new patients and new activity within the cochlear implant service presents a significant challenge and one which is compounded by the fact that every implant patient requires a lifetime of aftercare involving regular review of their health status and maintenance of their CI. Recruitment of additional staff to support this ongoing increase in demand is no longer a practicable solution as numbers of employees are restricted by the estate; with clinical rooms currently operating at high utilisation rates, the capacity of the estate has already been reached. Effective management of departmental growth requires the introduction of new pathways that reduce the footfall through the department, whilst maintaining access to the clinical support offered by experienced cochlear implant clinicians.
Aim**:** The advent of digital systems and healthcare integrated smartphone technologies provides a potential solution to support the management of these patients. This technology provides a potential opportunity to change the way we deliver services; introducing new, more efficient pathways for patients, placing value on their time and releasing valuable clinical resources to support annual service growth. Our aim was to use a formal and structured approach to support the introduction and adoption of these technologies into the service.
Methods**:** The project was delivered following a formal change process; the Model for Improvement (Langley et al., 1996). Project Plans were developed and PDSA Cycles used to assess and study the impact and outcomes of the changes in service delivery. This presentation will provide the Audience with a detailed overview of the trial and adoption of new technologies used to support the remote delivery of the Cochlear Implant service over the last 2 years.
Outcome Measures: Measures of activity were considered to be a key indicator of the successful introduction of new remote technologies. In addition, gaining an understanding of patient and staff experience/satisfaction was considered a critical indication of improvement.
The following metrics formed a key dataset to establish the measures of improvement.
1. Percentage of patients signed up to Remote Check
2. Number of completed Remote Check pathways
3. Patient Experience/ Satisfaction.
4. Staff Experience/Satisfaction.

Conclusions**.** The process of implementing change presents a significant challenge for many NHS departments and leaders. Whilst many proposals for change offer solutions to the problems facing services, without staff engagement many change projects often fail. Early outcomes from this project are positive. Processes have been standardised and made more efficient whilst the system has been demonstrated to be highly usable for both patients and staff. This project forms a strong foundation to support the rollout of the remote/ e-health systems as the standard model for Cochlear Implant aftercare.
Keywords / Phrases: Remote care, Remote Programming, Digital Health, Electronic Health, Apps.

33 - mHealth supported hearing and vision services for preschool children in low-income communities

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Introduction Early detection of sensory impairments is essential towards facilitating early childhood development, socio-emotional well-being and academic success, as well as the Sustainable Development Goals (SDGs) related to education. Unfortunately, hearing and vision loss are the most common global developmental disabilities in children younger than 5 years of age affecting 15.5 and 25.2 million, respectively.

Children with disabilities in low-and middle income communities (LMICs) are often unsupported without timely detection due to the absence of systematic screening programmes along with prohibitive equipment cost and a shortage of trained personnel.
Objective This implementation research study aimed to describe and evaluate the feasibility of an implemented community-based service-delivery model for hearing and vision screening for preschool children using mHealth technologies. The performance of this service-delivery model will be described in terms of reach, referral rate, cost, community-based second screen return rates, fail rates after second screen and yield after referral to diagnostic centres. Implementation enablers and barriers were also explored in the implementation evaluation process.
Methods A combined sensory screening programme, which provides hearing and vision services to pre-school children by Community Health Workers (CHWs), was implemented in ECD centres in partially informal townships of the Western Cape, South Africa. Hearing and vision screening of all children (4 to 7 years of age) who returned their consent forms were done by the CHWs at the ECD centre using mHealth technology. An immediate rescreening was done if a child failed the first screening test. Children who referred the hearing screening had a community-based second screening at their ECD, including otoscopy. Children who failed this rescreen were referred to public health diagnostic audiology services. Children who referred the vision screening were provided diagnostic optometric evaluation appointments at primary health care facilities. If a sensory loss was identified during the diagnostic evaluation, the child was absorbed into the health system and further follow-up services and intervention were provided by public health services, for example hearing aid fittings, issuing of spectacles or medical intervention. An inventory was kept of all the costs and challenges encountered.
Materials Four CHWs from the community were recruited, appointed and trained to conduct the screening using mobile phone technologies. The hearScreen application (app) (hearX Group, SA) and Peek Acuity app (Peek Vision, UK) was operated on a Samsung A3 smartphone (Android OS, v8.0). Data collected by the smartphone were uploaded to a secure cloud-based server through cellular networks at the end of each test.
Findings During the first 22 months of implementation the hearing and vision of 10390 children were screened at 298 ECDs. An average of 500 children were screened monthly, at a cost of $5,63 per child. Overall first screening fail rate was 5.6% and 4.4% for hearing and vision respectively. The follow-up return rate for the community-based second hearing and vision screening was 88.5% and 88.1% respectively. One in three children were referred for a diagnostic evaluation at the second ECD hearing screening. 240 and 232 children, to date, have been diagnosed with a hearing- and vision loss respectively and referred for interventions. mHealth- and community enabling factors were found to contribute to the feasibility of the programme. The programme encountered a number of challenges that required mitigation strategies.
Conclusion In line with the 'leave no one behind' movement that supports the 4th SDG and Agenda 2030, mHealth supported hearing and vision screening facilitated by CHWs enable access to hearing and vision care for pre-school children in LMICs. A decentralized community-based service-delivery model requires a holistic approach including design, use of digital technology, training and monitoring of CHW, community partners and referral systems.

474 - WHISPER (Widespread Hearing Impairment Screening and PrEvention of Risk): a New Platform for Early Identification of Hearing Impairment and Cognitive Decline

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Background: Adult hearing screening can help increase awareness, identify the early signs of hearing impairment and therefore trigger timely intervention, thus preventing or delaying the progression of hearing impairment and limiting its impact on communication and psychosocial functioning. Speech-in-noise tests are valuable measures of hearing ability in real-life conditions and can be helpful to promote awareness and detect age-related hearing impairment at early stage. In the area of hearing loss prevention, a still largely unexplored area is related to the assessment of risk factors, including modifiable (e.g., cigarette smoking, noise exposure, medications) and non-modifiable risk factors (e.g., genetic predisposition, age, and co-morbidities such as diabetes and hypertension). Some risk factors are specific to hearing impairment whereas some others are common to hearing impairment and cognitive decline or dementia. To date, no standardized methodology is available to assess the risk of developing hearing impairment and the associated cognitive decline, and to help understand the potentially modifiable risk factors that determine the individual risk. The aim of this study was to develop and evaluate a novel user-operated platform to support widespread screening and prevention of

hearing impairment and the associated cognitive decline using a combination of speech-in-noise testing, cognitive testing, and risk factors assessment.
Methods**:** The proposed WHISPER (Widespread Hearing Impairment Screening and PrEvention of Risk) system is implemented on an easy-to-use graphical user interface and combines: (i) an adaptive speech-in-noise test based on multiple-choice recognition of vowel-consonant-vowel stimuli; (ii) an adaptive cognitive test, specifically the visual digit span working memory test (forward modality); and (iii) an icon-based interface to assess the main modifiable and non-modifiable risk factors for developing hearing impairment and cognitive decline. We have tested the platform on a total of >250 participants and we have extracted >30 features from the speech-in-noise test, the cognitive test, and the risk factors questionnaire. We have characterized the features using correlation and regression analysis and we have developed machine learning algorithms, including eXplainable AI techniques, to assess the relationships between the variables and the variables that are associated with hearing loss and cognitive decline.
Results**:** The accuracy of machine learning models to predict hearing loss (mild degree or higher) was higher than 90% using different combinations of input features. The highest performance was observed using a subset of features (i.e., age, speech recognition threshold, number of correct responses, number of trials, presence of cardiovascular diseases, and level of education), specifically sensitivity = 95%, specificity = 95%. The cognitive performance, as measured using several features extracted from the digit span test (e.g., digit span score, average reaction time per digit) was associated with speech recognition performance, with the pure-tone average, with age, and with the level of education. The analysis of psychometric functions of vowel-consonant-vowel stimuli, as estimated using the individual responses in the adaptive speech-in-noise test, revealed that additional features, in addition to the speech recognition threshold, could be extracted to further improve classification ability (e.g., slope, dispersion). Further research in this direction will be helpful to understand the optimal set of features for hearing loss classification. Results from user experience surveys (specifically, the user engagement questionnaire, UEQ, and net promoter score, NPS) showed that all the items of the UEQ were, on average, higher than 0 (neutrality score) and that 22 of the 26 items were higher than 0.8. The top ranked factors were perspicuity, efficiency, and novelty. The NPS showed that none of the tested subjects were classified as detractors and that they were nearly evenly distributed between neutrals and promoters.
Conclusions: This study showed that the WHISPER platform can accurately identify hearing loss in adults and that the platform is perceived as clear, efficient, and original by the tested subjects. Further research is needed to expand the set of features and develop models able to characterize the risk of developing hearing loss and the related cognitive decline on a larger population.
Acknowledgement:
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Keywords: hearing screening, cognitive decline, hearing loss, elderly, speech-in-noise test

REMOTE CARE, E- AND m-HEALTH SOLUTIONS (2)

493 - Validation of an internet-based digit-in-noise hearing screening test

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Background: The use of digits-in-noise (DIN) tests for clinical and research purposes increased during recent years. This is partly since DIN tests, amongst other speech-in-noise tests, show a promise to act as potential valid online hearing screening tool. However, such tests need to be validated against the clinical pure tone audiometry before they can be recommended for routine hearing screening in general population. Manchester Online Speech-Perception Suite (MOSS) is an online application consisting of a battery of speech-in-noise tests including DIN test, however, yet to be verified for online hearing screening.
Objective: The aim of this study was to validate the DIN test incorporated in MOSS for use as an online hearing screening tool for adults. The impact of a controlled versus uncontrolled environment and potential learning effect on DIN-test results were assessed.

Design**:** Sixteen young, native English-speaking adults with self-reported normal hearing participated in the study. Each participant completed the following tests: a) DIN test performed in uncontrolled settings (at home), using personal devices; b) DIN test performed in sound-proof clinical room using the computer with high-quality sound card and Sennheiser HD600 headphones; c) pure-tone audiometric threshold test (including extended high-frequency audiometry) performed in sound-proof clinical room.
The validation of online DIN was achieved by comparing speech reception thresholds measured online in uncontrolled environment with the DIN results obtained in clinics, i.e. in controlled settings. Additionally, the performance of the online DIN was assessed against clinical audiometric findings for four-frequency and for extended high-frequency pure-tone audiometric threshold averages.
Results**:** There was no significant difference between the results of DIN test completed at home and the results obtained in controlled clinical environment. There was no improvement in performance related to the learning effect as no statistically significant difference was observed between first and second test result.
Conclusions**:** The online DIN test was found to be robust enough to be completed in uncontrolled environment with personal device and headphones/earphones giving the results comparable to these obtained in the clinic. Further research is required investigating DIN test benefit as a clinical tool in the screening for hearing loss, as this study provides only preliminary findings from normal hearing individuals.

400 - Hearing Healthcare for all: utilizing mHealth and mobile platforms to eradicate inequality in access to hearing services across the world

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Access to ear, nose and throat (ENT) specialists around the world is limited by lengthy waiting lists and a lack of specialists, especially in rural and remote areas. This has been compounded by the SARS-Cov-2/COVID-19 pandemic, which has placed a significant additional strain on routine outpatient appointments. Delays to ear and hearing consultations/interventions can have dramatic and life-changing consequences on children and young people's (CYP) development, affecting their quality of life, school attainment, and their mental health. Significant innovations in health service design and delivery are required to ensure sustainable and equitable access to hearing healthcare across the life course for all.
To address these problems, we conducted an acceptability and feasibility study of a teleotology (telemedicine for ear and hearing disorders) service at a tertiary paediatric ENT department in the United Kingdom. Our department serves a geographically and socio-economically diverse population with some CYP struggling to access specialist hearing healthcare due distance and expense of travel, a depleted workforce, and an increasing population. Teleotology offers a route to widening access to specialist hearing healthcare, and improvements in patient experience through more efficient service delivery, for CYP in the UK and around the globe.
Our aims were to investigate the acceptability and feasibility of a smartphone otoscopy in CYP and to explore the experiences of teleotology amongst CYP, parents/carers, and other stakeholders (e.g. healthcare providers).
Our specific objectives were to:

- assess the adequacy of captured images/videos for making remote diagnoses;
- determine if there are any groups of children and young people for who teleotology is unsuitable;
- explore the stakeholders' views and experiences of the service.

We performed a pilot study of a paediatric teleotology service between community Audiologists and the busiest paediatric ENT department in the United Kingdom. CYP attending for a routine ear and hearing assessment by an Audiologist were assessed using a smartphone otoscope with a bespoke app that could record and send still and moving images. Three ENT specialists at a remote location asynchronously assessed the adequacy of captured images/videos. Stakeholder views were assessed using questionnaires and semi-structured interviews.
The preliminary results of our study will be presented, and situated more broadly within the field via the outcomes of a systematic review of published literature from 2016 to 2021, examining recent advances in mHealth and mobile platforms that facilitate remote diagnosis and triage for ear and hearing disorders. Systematic database searches (EMBASE, MEDLINE, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews) yielded 29 outputs for consideration. One duplicate was removed, leaving 28 abstracts and titles which were then screened for relevance, resulting in 19 papers for full text

review. We share lessons learnt, discuss barriers to wider adoption and highlight strategies to overcome them, and finally, consider how computer algorithms may enhance teleotology in the future.
Keywords: Ear disease, Hearing impairment, mHealth, Telehealth, Healthcare access

172 - Studying the auditory ecology of older people using the mobile smartphone-based system olMEGA
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Background: One-third of people over the age of 65 have a hearing impairment (HI) that affects everyday communication. HI is also associated with several physical, cognitive, and psychosocial health problems. Reducing the impact of HI and supporting healthy aging are considered important public health goals. Most everyday situations contain some form of background noise, and even low levels can interfere with speech perception and communication. Hearing aids have only limited capacity to separate wanted sounds, such as speech, from unwanted sounds, such as background noise, hence offer limited value in noisy environments. As a result, people with HI often experience listening effort and fatigue. We need to generate new knowledge about the auditory ecology encountered by older people and how it interacts with individual factors, and to apply this knowledge to ensure ergonomic listening for this group.
Purpose: The purpose of the project is twofold: Firstly, to investigate the auditory ecology encountered by older people in their daily lives, and secondly to investigate how auditory ecology affects their speech perception and communicative efficiency.
Method**:** The project includes three studies. In Study 1, we will investigate auditory ecology in real-time using our novel version of Ecological Momentary Assessment (EMA). Our mobile smartphone-based EMA system (olMEGA) combines objective (yet privacy preserving) recording of acoustic parameters with subjective assessment (listening activity, listening effort, speech understanding, motivation, and acoustic environment). In Studies 2 and 3 we will investigate how the auditory ecology identified in Study 1 affects speech perception (Study 2) and communicative efficiency (Study 3) in older people, under controlled laboratory conditions. Participant-specific listening environments, extracted from EMA, will be modelled and used as maskers. In Study 2, we will use the Swedish hearing in noise test (HINT) to study the effect of auditory ecology identified using EMA on speech recognition. In Study 3, we will use Diapix (a 'spot the difference' picture task performed in pairs) to study the effect of auditory ecology identified using EMA on communicative efficiency. In Study 3, we will also study associations between communicative efficiency and listening effort, fatigue, cognitive abilities, motivation, quality of life and psychosocial health. For the project, we will recruit 72 participants aged 65 – 80 years (with equal numbers of men and women). This is required to achieve 95% power for ANOVA's and 80% power for correlations. Half of the sample (36 participants) will take part in all three studies. The other 36 participants (matched on age and gender to the first group) will take part as dialogue partners in study 3. We will test hearing, screen for cognitive decline and assess quality of life, psychosocial health, and hearing disability for all 72 participants.
Implications**:** The results can be used to facilitate active and healthy aging by promoting ergonomic listening and increased participation. Results will also form a knowledge base for good auditory ecology and better hearing rehabilitation for older people.

362 - Administering language assessments to Paediatric Cochlear Implant patients via Telehealth; an evaluation
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Introduction and Objectives Telehealth can benefit patient experience; providing flexible access to services at greater convenience. Telehealth has proved an effective provision for Audiology services and Speech and Language Therapy (SLT) with other client groups. The Covid-19 Pandemic provided the SLT team at YAIS with an opportunity to trial telehealth with our paediatric Cochlear Implant (CI) users and evaluate it as a service delivery method.
Methods Children on the caseload within their 3rd to 6th year post implant were identified. Parents of children who met inclusion criteria were given the option to attend their child's routine SLT review remotely via Microsoft Teams. To ensure consistency between face to face and telehealth appointments we used digital versions of routinely used assessments which were supported by the relevant publishers. Feedback from patients and parents will be gathered in the form of a questionnaire. Therapists will complete evaluation forms after each

session, answering open questions about what worked well and what did not and forms will be thematically analysed.
Results Qualitative information will be used to discuss the challenges and considerations we face in setting up a telehealth service viable for CI users and their families. We will evaluate patient, parent and clinician perceived benefits and limitations of telehealth for language assessment.
Conclusion We will discuss the wider challenges of providing an equitable service. We hypothesise a conclusion that telehealth is a valuable option for families to be offered in conjunction with face-to-face appointments. We recommend that limitations be discussed openly with families. We hope our evaluation is informative for other CI Rehabilitation teams deciding whether to offer telehealth or purchase digital formats of staple assessments.

428 - Assessments in The Cloud: Integrating digital technologies into the cochlear implant clinic using implementation science

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Background Improvements in cochlear implant (CI) technology, in addition to changes in candidacy criteria and funding over the last decade, have seen vast increases in the number of people eligible for implants. Despite this, in Australia, only 10% of adults eligible for a CI actually receives one. These statistics are even poorer globally, therefore there is a strong drive globally to improve CI uptake rates. In 2019, Cochlear Ltd forecast a 10.5% mean annual global growth in hearing implants to 2026.
CI services are typically provided by limited numbers of specialised staff via centralised implant clinics and face-to-face appointments. The combination of social distancing requirements brought about by the current COVID-19 pandemic, in addition to the predicted growth in the penetration of hearing implants, highlight that continuing with the status quo will be unmanageable. Therefore alternative options are required to manage CI recipients. One alternative is the use of e-health technology. A recent survey has shown that the use of e-health services is significantly lower in Australian adults with hearing loss (27%) compared to the general population (48%). A major barrier to the use of digital technologies is the difficulty people with hearing loss experience communicating in phone or video consultations. In addition, the demographic of adults with hearing loss is generally older, and service users and providers alike often perceive a lack capability for digital literacy skills. Newer technologies that rely less on hearing could be a solution but may also present a challenge for older adults.
Cochlear Ltd has developed an asynchronous e-health at-home testing system (Remote Check) that allows CI users to assess domains commonly assessed during a standard CI review, including speech perception, subjective hearing difficulty and electrode impedances. The aims of this research were to conduct (i) a feasibility study, and (ii) an implementation study on the use of Remote Check for long-term CI management.
Methods For the feasibility study, sixteen CI users participated, all implanted with Cochlear Ltd implants and using the Nucleus 7 sound processor, age range 20-85 years (median 69 years). Speech perception was assessed using the Digit Triplet Test (DTT) via Remote check, and freefield-delivered CNC word test and BKB-SIN sentence test. Aided audiograms were assessed via Remote Check. Participant's acceptance of Remote Check was also obtained. Assessments were completed at baseline, and at 1 week, 1 month and 6 months post-baseline.
For the implementation study, focus groups will inform a discrete choice experiment, the results of which will be used to design the new service provision and implementation pathway.
Results For the feasibility study, there were significant negative correlations between DTT score and CNC word ($r = -0.62$, $p = 0.02$) and phoneme ($r = -0.54$, $p = 0.04$) scores, but no correlation between DTT and BKB scores ($r = 0.01$, $p = 0.98$). A repeated-measures ANOVA showed a significant improvement in DTT scores from baseline to 1 and 6 months (mean=1.2 dB, $p = 0.04$; mean=1.8 dB, $p=0.02$) respectively. Aided audiogram results via Remote Check showed non-significant minimal changes of -0.8 dB, -0.6 dB, and -1.1 dB at 1-week, 1 and 6 months respectively.
The vast majority of participants were either likely or highly likely to accept future Remote Check appointments at baseline (92%), 1-week and 1-month post-baseline (100%) and at 6-months post- baseline. All participants found Remote Check somewhat to very easy to use at baseline, between 83% to 92% across all four appointments. Recommendation of Remote Check to others was ranked highly, between 8.7 and 9.1, across all appointments (where 1=unlikely, 10=very likely). The implementation study of Remote Check is underway, and results will be presented.

Discussion The feasibility study showed that Remote Check is valid, acceptable and feasible for clinical management of CI users. A significant barrier to the uptake of e-health services is their integration into standard clinical care. In addition, the low uptake of e-health services for CI management will result in continued inequitable access for CI users, and unmanageable caseloads for CI clinics. Therefore, using implementation science, we aim to better understand how to successfully employ Remote Check in the clinical setting to provide sustainable services for the future.

190 - Game-based hearing screening tool for children

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It is known that good hearing is essential for the learning ability of children, and untreated hearing loss is a big challenge throughout the entire world. Hearing screening of school aged children is essential to detect those with hearing challenges, but current tools often require skilled personnel and specialized equipment. This is especially problematic in low-income countries, and the consequence is often that no systematic hearing screening is performed. Many children will therefore go undetected, leading to both reduced learning outcome and even school drop-out. Low-cost hearing screening tools that can be used by non-skilled personnel is therefore one step towards a better situation for many children. This is directly related to the UN sustainable development goals on "quality education" (goal 4), "good health and well-being" (goal 3) and will eventually also reduce poverty (goal 1). There are, however, several challenges that needs to be solved before such hearing screening tool will work as intended.
In an ongoing research project, a game-based hearing screening tool is being developed, using relatively cheap off the shelf equipment. The hearing test uses an automatic procedure to determine the hearing threshold of the test subjects, and the game concept is that animal sounds are presented and the test subject should push an animal to give a response. An iterative process has been used to develop the tool, and several challenges have been discovered throughout the development phase. The goal is to come up with a screening tool that can be used locally at schools by non-trained personnel, and the results from the tool will be used in a decision support system that can give guidance to what measures should be initiated. These measures can for instance be direct interventions such as removal of cerumen and treatment of ear infections, information to the teachers about how the child can be helped to get a better speech signal and use of assistive technology (hearing aids and personal amplifiers). The latter is, however, often a challenge in low-income countries because of both expensive equipment and lack of technical support.
The presentation will give a technical description of the hearing screening tool and discuss the choices that have been made and the consequences of them. Additionally, the experiences gained throughout the iterative process, and results showing how the screening tool performs will be shown.
Keywords: Game-based hearing screening, children.

392 - Web- and App-Based Tools for Remote Hearing Assessment: A Scoping Review

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Remote hearing screening and assessment may improve access to, and uptake of, hearing care. This review, the most comprehensive to date, aimed to: (i) identify and assess the functionality of remote hearing assessment tools on smartphones and online platforms, (ii) determine if the tools had been validated in peer-reviewed publications; and (iii) report on the accuracy and reliability of any existing validation data. The protocol was registered in the International Platform of Registered Systematic Review and Meta-Analysis Protocols and reported according to the guidelines of the PRISMA-Extension for Scoping Reviews. A total of 187 remote hearing assessment tools and 101 validation studies identified that met the inclusion criteria. The tools were heterogeneous in terms of accuracy, quality, compatibility, supported languages, output formats, and hearing assessment methods (Tone, Speech, Self-Reported or Mixed-Methods). The number of tools with validation data was relatively low, and not all had high-quality functionality and accuracy. Tone tools can provide users with approximated hearing thresholds but are prone to calibration and background noise issues. Speech tools are less affected by these issues, but most do not provide users with an approximated audiogram. Predicting

audiograms using filtered language-independent materials (e.g. nonsense words) could be a universal solution.

HEARING CARE IN LOW- AND MIDDLE-INCOME AREAS

205 - Development and Implementation of National Strategic Plans for Ear and Hearing care in Low and Middle-income Countries; the Starkey Hearing Foundation (SHF) approach in a dozen countries

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Background: The World Health Organization in 2018 estimated that 466 million people suffer from disabling hearing loss globally with 80% of them residing in low and middle-income countries (LMICs). Unfortunately, most countries especially LMICs do not have any roadmap to tackle the scourge; a WHO multi-country assesment revealed aly 42 member states have some form of national or sub-national plan for ear and hearing care in their countries. On the contrary WHO member states ratified the Agenda item 15.8 of 70th World Health Assembly in May 2017 with a resolution enjoining them to develop National Strategic Plans for Ear and Hearing care (NSPEHC) that is integrated into the primary healthcare system under the umbrella of the universal healthcare coverage. SHF has championed the cause to support many countries in developing NSPEHC to include: Kenya, Rwanda, Nigeria, the Gambia, Uganda, Tanzania and Malawi in sub-Saharan Africa, Jamaica and St Lucia in the Caribbean, Elsalvador in central America and Armenia in Europe.
Objective**:** To support low and middle-income countries in developing and implementing national plans to improve ear and hearing care, which aims to reduce the prevalance, incidence and impact of hearing loss on individuals, families and communities through public health approaches.
Methodology We utilized the WHO ear and hearing care situation analysis tool and the manual for planning and monitoring national strategies as our guiding template. The national strategies were built upon the WHO six health systems building blocks as it relates to ear and hearing care. Summary of steps taken include: initial advocacy visits to the Honorable ministers of health's team, setting up a technical working group, having 3 technical sessions each lasting 2 days on the average, a validation exercise through an expanded stakeholder's forum, the document launches and dissemination, inauguration of implementation committee and commencement of implementation.
Expected Outcome In the short term, the countries have completed the development of their national plans and are at different stages of implementation. In the long term, a reduction in incidence, prevalence and the negative impact of ear diseases and hearing loss in the countries implementing the national plans.
Minimum Learning Objectives

- How to advocate to governments on the need for National plans for ear and hearing care
- The process of leading the development and implemntation of a National plan in low and middle-income countries
- Translating the plans into actions that will impact ear and hearing care of the common man in these countries.

Key words: Hearing loss, National Strategic Plan, Development. Policy, Low and middle-income countries, implementation

98 - Training on Ear and Hearing Care for Community Health Workers: CBM field testing of World Health Organisation resources in India

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Background: CBM is a non-State actor in official relations with the World Health Organisation (WHO) since 1989 and, as such, provides technical advice and supports the design, revision, publication, dissemination and

use of WHO's training resources and tools among its Member States, specifically in low- and middle- income countries. Objectives**:** To field-test the revised version of WHO's Primary Ear and Hearing Care training resources (PEHC-TR) alongside local field workers and health specialists. This, by delivering Training of Trainers (TOT) workshops, obtaining participants' direct feedback and determining if the PEHC-TR are successfully updated to meet current needs for raising awareness and capacity building of Community Health Workers (CHWs) and Primary Health Care workers. Materials**:** WHO's revised (still ongoing) PEHC-TR were used for this TOT and field testing activity: specifically, the "Basic Ear and Hearing Care Resource" and "Primary Ear and Hearing Care: Training Manual for health workers". Two TOT workshops lasting three days each, were delivered to CHWs actively involved in their respective populations of influence in Vellore and Mugalur. Facilitators included two experienced CBM advisors (one educator and one ENT surgeon) with ample experience in PEHC teaching, design/revision of training resources and in public health interventions in low- and middle- income countries. Local facilitators included CBM partners: CMC-Vellore and St John's Hospital-Bengaluru, led by experienced Community Health Doctors, Audiologists and Hearing Aid Technicians. This activity was funded and supported by CBM-International Office in Germany and by CBM-Country Office (CO) in India, led by the India office team in coordination with local partners. Methods**:** Suitable dates were chosen, locations agreed, number of participants and background were defined. A mixture of 34 rural and remote tribal CHWs were selected for TOT in Vellore, which included different levels of training and experience in PEHC. For the TOT in Mugalur, it was decided to choose 20 rural CHWs with no previous experience or training in PEHC. Local organising teams received detailed information about the PEHC-TR, TOT objectives and practical issues. Live translation during ToT workshops and printed feedback questionnaires were provided into local languages (Tamil and Kannada). Feedback was produced as a combination of numeric responses to fifteen questions (rating 1 to 10) and narrative responses to six open questions. CBM CO-India kindly translated the narrative responses into English. Results**:** There was an overwhelming positive feedback reflected in the response rating from participants, related both the usefulness of these training resources for daily work and also for their personal and community habits and living conditions. Contents of the PEHC-TR were found to be well chosen and comprehensive. Factors highlighted for the success of the TOT workshops and the good reception of the WHO PEHC-TRs are summarised as follows: The combination of multimedia theory teaching alongside practical demonstrations, individual exercises, role play in pairs and small group work; The opportunity to hear first-hand the experiences from persons living with hearing disability and the challenges faced, and; The possibility to know, learn from and directly interact with local and international health specialists. Constructive feedback was also provided for some specific contents to be revised or further adapted, however, there was no section of the manuals which was deemed to be irrelevant or unnecessary, from the participants' point of view. Other results based on specific contents, TOT methods used and practical feedback received will be provided during oral presentation, should this abstract be accepted.
Conclusions**:** This project's experience provides an excellent example to illustrate the positive impact of strategic interventions directly implemented in local communities. The choice of a multidisciplinary and inclusive approach for this CBM programmatic and technical training activity, contributed towards facilitating a natural and effective partnership among stakeholders at international and country levels. Furthermore, it demonstrated how Audiology and ENT professionals can collaborate with community based workers, in order to strengthen local and National Systems, as well as to the dissemination and improvement of WHO-led training resources. Further PEHC-TR revision and field research into positive impact of these TOT programme is still required, but consensus is that we are in the right track.

209 - Early Intervention - New Programme in Kyrgyztan

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The Kyrgyz Republic is one of the five ex-USSR countries in Central Asia. With an area of close to 200 km² it is comparable in size to Great Britain, whereas the population (6,2 Mio) is only one tenth of the 62,1 Million in Great Britain. Kyrgyzstan has borders with Kazakhstan, Uzbekistan, Tajikistan and China.
The country is part of the Silk Road and has many very high mountains. The name „Kyrgyz" is derived from the Turkish word „fourty". In the 9th century the legendary hero Manas united forty clans against the Uyghurs, and the word „stan" is Persian origin and means „country". The flag of Kyrgyzstan with the 40 ray yellow sun is a reference to this.
The health care system suffered increasing shortages of health professionals and medicine in the post- Soviet era. The state-supported system deteriorated, maternal mortality is still very high. No wonder that Neonatal Hearing Screening (NHS) has been introduced only very recently and sporadically. It is far from routine. The government funds neither hearing aids nor cochlear implants.

The Lehnhardt Foundation is connected to Kyrgyzstan's health care system since 2014, when the first two children from Bishkek with the help of our foundation got a cochlear implant at the University Clinic in St. Pölten, Austria. In 2018 the Lehnhardt Foundation signed a cooperation agreement with the 'National Centre of Maternity and Childhood Care' and, together with the Foundation „Place", donated NHS-Screening and Diagnostics Equipment (OAE , ABR, ASSR). Training on how to use the equipment was/is done by Peter Zoth locally as well as regularly Online from Germany. He is a board member of the Lehnhardt Foundation and co-founder of the foundation „Place".
It was obvious to us that many more children should get this treatment, providing surgeries could be done locally. Therefore we supported families to get funding and with the help from Prof. Vladimir Fedoseev, a surgeon from Moscow, we managed that another eleven children to get CI – 2019 at the 'National Center of Maternity and Childhood Care'. The Lehnhardt foundation orchestrated that these children had the first fitting of their speech processor with an audiologist from Kiev (Dmitrij Zayjka). Marina Gureva - a very experienced therapist from St. Petersburg - worked intensively with the families and their children (also online). In December 2019 the Lehnhardt foundation submitted two projects to GIZ (German Organization for International Cooperation) in order to support:
- one project on Cochlear Implantation (start 2019) and
- one project on Early Intervention / Implementation of countrywide Neonatal Hearing Screening (start 2020).
Both projects are now supported financially by GIZ for the next 2 years.
As part of the the first project, Prof. Dr. Tino Just (KMG Clinic Güstrow) implanted additional 10 children at the 'National Center of Maternity and Childhood Care' in December 2020 instructing local surgeons at the same time. While the Lehnhardt foundation since 2014 supported 51 children in order to receive Cochlear Implants the total number in Kyrgistan might be more then 200.
Some were invited for a cost-free surgery to Turkey, some travelled to countries in Europe.
Only recently, with the help of the Lehnhardt foundation and the state of Quatar, surgery could be done locally at Bishkek for 20 children and local surgeons have been trained. In 2020 we started Neonatal Hearing Screening (NHS) in 4 delivery clinics as a Pilot Program across the country. The screening protocol is composed of OAE & ABR testing. The complete NHS-protocol including diagnostics and rehabilitiation was proposed and accepted by the Ministry of Health of Kirgistan.
Currently we are implementing a 'Tracking Center' at the Bishkek in order to control the 'Lost to follow-up' rate.
It is planned to establish one additional Diagnostic-Center in the city of Osh.
Early 2022 first data will be available and published.

ADVANCES IN AUDITORY EVOKED RESPONSES

276 - Speech Induced Binaural Beats in Free Field: Electrophysiological Assessment of Binaural Interaction

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Assessment of binaural interaction plays an important part in the diagnosis of central auditory processing disorders (CAPDs). Apart from psychoacoustic tests, electrophysiological correlates of binaural interaction are usually obtained by measuring the binaural interaction component of the auditory brainstem response (ABR-BIC). The ABR-BIC contains however no information regarding higher brain structures, often suffers from a low signal-to-noise ratio (SNR), and may even be absent in healthy subjects. We recently introduced a stimulus manipulation scheme, which allows us to manipulate any speech signal to contain a transient Speech induced Binaural Beat (SBB), while the speech still sounds naturally. When presented monaurally, the SBB cannot be perceived. Only upon binaural presentation of the dichotic stereo signal, a transient SBB is perceptible. We recruited 19 normal hearing subjects (28.8 ± 2.5 years old, 13 male and 6 female) and recorded EEG at the left and right mastoids (M1/2) with reference placed at the vertex (Cz) and ground at the upper forehead (Fpz). Using loudspeakers, placed 1 m away from the subjects' head at ±90°, we presented sentences from a German sentence matrix test for speech intelligibility (OLSA: Oldenburger Satztest) that contained SBBs in various words. We performed recordings under different conditions: speech without noise, speech with digitally mixed noise, and speech with a separate noise source (from a loudspeaker behind the subject). In each condition, which lasted ~10 minutes, 150 sentences were presented. If noise was present, the SNR was set to +2.37 dB.

During the measurements, subjects were instructed to press a button whenever they perceived a SBB. The results revealed that in all conditions, whether with or without noise, late auditory evoked potentials (LAEPs) - most notably the N1 at 128-138 ms - could reliably be recorded in all 19 included subjects. Because those LAEPs can only be recorded under dichotic, but not under diotic stimulus presentation, they are a pure correlate of binaural interaction. Comparing this to the ABR-BIC, in which two monaural measurements are subtracted from a third, binaural measurement, only one measurement is required for SBB. Additionally, since LAEPs are of cortical origin, they have a higher SNR than ABRs and implicitly require functional subcortical structures. To exclude possible influences of acoustic interference of the waveforms, we conducted additional measurements in which one ear was completely occluded. When the ear was occluded, no LAEPs could be evoked. When the occlusion was removed, LAEPs could again be recorded. These results demonstrate that SBB can be used to record objective correlates of binaural interaction on the cortical level in a free field, using clinically used speech material (e.g. for speech-recognition thresholds), even when noise is added. While there are still open questions, e.g. the influence of different SNRs, we hope that this stimulus may at some point play a part in the larger testing battery for CAPDs.

376 - Measuring earlier components of auditory brainstem responses from modified speech

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Background. The auditory brainstem response (ABR) is a powerful measurement to assess hearing condition objectively and passively. ABR is typically elicited from non-speech sounds such as clicks. The neural responses to these sounds can be averaged to reveal the ABR waveform that consists of Waves Ⅰ-Ⅴ. Each individual wave component of the ABR is associated with a different subcortical structure along the auditory pathway, and can be used to estimate audiograms for individuals. Most of the ABR studies and clinical trials have been done with thousands of non-speech clicks. Very recent research has derived ABR from naturally uttered speech, yet these approaches generally only reveal later ABR waves such as Wave Ⅴ (Forte et al., 2017; Maddox & Lee, 2018). Polonenko and Maddox (2021) for the first time derived clear Wave Ⅰ, Ⅲ, and Ⅴ from their “peaky” speech; however, their method involves great modification of the speech stimuli with computationally intensive pre-processing, which makes it sound less natural and unlikely to be used in real-time conversations. In our study, we implemented an alternative, computationally efficient speech modification algorithm -- the transient enhanced speech, to elicit speech-derived ABR. Such an approach may allow for fast ABR-based hearing assessments in more natural conditions with little to no burden placed on the user. Moreover, studies have found behavioral benefits, e.g. higher intelligibility in noisy background, by emphasizing transients in speech. We first tested the unaltered and modified speech stimuli vs. clicks with an auditory periphery model (Verhulst et al, 2018) to compare the model output ABR Wave Ⅰ, Ⅲ and Ⅴ. Using EEG, we then replicated Polonenko and Maddox (2021) results of the peaky speech. Finally we used the same deconvolution analysis as Polonenko and Maddox (2021) but presenting subjects with our transient speech. Methods**.** Ten subjects were recruited in this pilot study for replicating Polonenko and Maddox’s peaky speech (n = 2) and testing our transient speech (n = 8). They were seated comfortably on a couch with a neck supporting pillow and a leg reclining chair. A section of audiobook was delivered via ER-2 insert earphones (Etymotic Research, Elk Grove, IL) to both ears in 65 dB SPL. At the same time, EEG was recorded using the EP-Preamp system with Multitrodes placed at Cz (non-inverting), right mastoid (inverting reference), and the high forehead (ground), all manufactured by BrainVision (Morrisville,NC). Data were sampled at 25 kHz and offline high-pass filtered between 150 and 2000 Hz for the speech-derived ABR using a first-order causal Butterworth filter. Preliminary results. The stimuli fed into the auditory periphery model were 5 s of clicks and 16 s of speech, including Polonenko and Maddox’s peaky speech, our transient speech and unaltered speech as the control. The regressors of the deconvolution analysis were click train, glottal pulse train, transient train and rectified speech signal, respectively. Observing the model output, we found the highest similarity of ABR morphology between clicks and peaky speech, with both showing distinct Wave Ⅰ, Ⅲ and Ⅴ. We also observed Wave Ⅰ, Ⅲ and Ⅴ in transient and unaltered speech, while with more variability especially in Wave Ⅰ. To further test our transient speech, we first demonstrated that the measured ABR derived from peaky speech replicated Polonenko and Maddox’s results, showing Wave Ⅰ and Ⅴ in one subject and Wave Ⅰ, Ⅲ and Ⅴ in the other subject. Compared to the ABR derived from peaky speech, the measured ABR derived from the transient speech revealed more prominent earlier peaks before Wave Ⅴ, although with more variability across subjects. **Discussion.** This study compared ABR elicited by different modified speech samples. We found that peaky-speech ABRs still resemble click ABRs the most, but its process requires heavy

computation and results in unnatural-sounding output. The transient speech proposed by our study not only improves hearing in noisy environments as described in past studies, but also showed more prominent early ABR waves with lower computational complexity. Transient speech may serve as an alternative, real-time speech-enhancing algorithm to elicit ABR for hearing assessment and ultimately contribute to future clinical and real world implications.
Keywords: speech transients, speech modification, speech-derived ABR, deconvolution, auditory periphery model

244 - Bone conduction ABR stimulus level corrections in babies at 4 kHz
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Background: Ferm et al, 2014[1] completed a study to estimate the bone conduction (BC) stimulus level corrections for Auditory Brainstem Response (ABR) tone pips at 500 Hz and 1 kHz of normally hearing newborns using a calibration reference level derived by BSA/NHSP from ISO 389[2] values. The aim of this current study is to extend the study to check the appropriateness of the current BSA corrections[3] used for bone conduction ABR testing of newborns at 4 kHz using tone pips.
Method: Bone conduction ABR tests were performed on 19 newborn hearing screening referrals (23 ears, average age 3 weeks corrected age and age range -1 to 16 weeks) who passed an ABR discharge criterion at 4 kHz, to establish essentially normal hearing. Tone pips were presented via supra-aural earphones and a bone vibrator at 4 kHz. Tympanometry was completed on all ears and indicated normal middle ear function. ABR thresholds from both transducers were compared, to assess any air-bone gap.
Results: Median uncorrected air and bone conduction ABR threshold difference was 10 dB for 4 kHz tone pips.
Conclusion: The current English stimulus level corrections for ABR tone pip testing of newborns at 4 kHz are -10 dB for supra-aural earphones and +0 dB for bone vibrator. Once these corrections are applied the median air-bone gap is 0 dB. This confirms that the current corrections for 4 kHz tone pips appropriate for this age group.
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2. ISO 389-6 (2007) Acoustics - Reference zero for the calibration of audiometric equipment - Part 6: Reference threshold of hearing for test signals of short duration.
3. NHSP / BSA Guidelines for the early audiological assessment and management of babies referred from the Newborn Hearing Screening Programme, Version 3.1, July 2013 (Currently under review but it is understood that the forthcoming version will provide identical BC corrections)

375 - A novel approach to measure speech-derived ABR: Comparison between Cz and in-ear TipTrode using click and speech sound
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Background. The auditory brainstem response (ABR) is a powerful measurement to assess hearing condition objectively and passively. Each individual component of the average ABR can be associated with a different subcortical structure along the auditory pathway: Wave Ⅰ and Ⅱ (~1.5 - 3 ms) are from the auditory nerve; Wave Ⅲ (~4 ms) is from the cochlear nucleus; Wave Ⅳ (~5 ms) is from the lateral lemniscus and Wave Ⅴ (~ 6 ms) is from the inferior colliculus. Although ABR is typically recorded from the scalp electrode placed at Cz, earlier research has found higher SNR, especially for the earlier ABR waves such as Wave Ⅰ, by placing electrodes in the ear canals. Based on these studies, the ABR measurement setup could be further simplified, while maintaining similar or even higher signal quality with a type of specialized electrode -- the TipTrode (Etymotic Research, Elk Grove, IL). TipTrode has several advantages over traditional EEG that requires geling. First, TipTrode enables a fast and easy setup. It also acts as a sound-stimulus delivery device as well as the EEG recording device. These strengths promise higher compatibility with real-life applications. Second, researchers can easily instruct subjects to put in the TipTrode like earphones and collect viable data without physical contact and proximity, which is important during a pandemic. However, surprisingly little research has

been done to compare ABR recorded from Tiptrode and Cz. Moreover, instead of using more natural sound stimuli such as speech, previous studies only used TipTrodes to measure click-evoked ABRs. In this pilot study, we compared ABR morphology simultaneously recorded from Cz and TipTrode when subjects listened to clicks. After validating this important first step, we used TipTrode to record ABR when the subject listened to more ecologically valid continuous speech. Methods**.** Four subjects were recruited in this pilot study. EEG was recorded using the EP-Preamp specifically designed for recording ABRs (Brain Vision, Morrisville, NC). Multitrodes were placed at Cz (non-inverting), right mastoid (inverting reference), and the high forehead (ground). In addition, we customized the gold-foil of ER3–26A/B TipTrode cable to be compatible with the EP-Preamp system so that we could record Cz and TipTrode simultaneously. Data were sampled at 25 kHz and offline high-pass filtered between 100 and 3000 Hz for the click-evoked ABR and 150 and 2000 Hz for the speech-derived ABR using a first-order causal Butterworth filter. TipTrode was placed inside the left ear canal. Sound stimuli were delivered via ER-2 insert earphones (Etymotic Research, Elk Grove, IL) to the right ear. We collected click-evoked ABR from 3 subjects. A total of 13200 100-μsec clicks (5 mins) at 76 dB peSPL were presented in randomized inter-stimulus intervals with alternating polarity to prevent stimulus artifacts. We collected speech-derived ABR from 2 subjects. Part of the audiobook *The Alchemyst* (Scott, 2007), read by a male narrator, was modified to be “peaky” and presented in 65 dB SPL to best elicit ABR based on Polonenko and Maddox (2021). Preliminary results. We acquired click-evoked ABR by traditional averaging across click presentations that are lower than the threshold 5 mV epochs with signal amplitude larger than 5 mV were considered to be noise). For the speech-derived ABR, we used linear least-squares regression to calculate the responses, as in previous work (Lalor et al., 2009; Maddox & Lee, 2018; Polonenko & Maddox, 2021). The results showed a similar click-evoked ABR morphology between Cz and Tiptrode for both subjects. Pearson correlation showed high correlation (ρ > 0.7 and p < 0.000) between the waveform measured from Cz and Tiptrode for all subjects. We also observed ABR waveforms from continuous speech. The derived ABR showed more clear Wave Ⅰ, Ⅲ and Ⅴ. **Discussion.** We showed a great potential of applying Tiptrode to measure ABR from continuous speech by revealing clear earlier waves. Although we observed higher variability for the TipTrode than Cz, the correlation between the two was high. Future research will replicate our pilot study with a larger and more diverse set of subjects. If successful, this approach may have great potential to apply in clinical measurements and products such as VR headsets and AR glasses.
Keywords: EEG, TipTrodes, click-evoked ABR, speech-derived ABR

370 - Registration of Auditory Steady State Response of the Brain in a Free Sound Field in Young Children

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The aim of the study was to determine the correlation of ASSR thresholds with the supply of a stimulus in a free sound field with the responses received during stimulation through headphones and the values of play threshold audiometry in a free sound field in children with normal and hearing loss.
Material and methods of research. In National Medical Center Republic of Tajikistan "Shifobakhsh" of the ENT clinic we examined 20 young children (1-3 years old) with normal hearing (group 1) and 20 children of the same age with hearing loss of high - IV degree (group 2).
All the subjects underwent play threshold audiometry for preliminary confirmation of the state of the thresholds of sound transmission and sound perception.
Play threshold audiometry in a free sound field was performed using a clinical audiometer MA-31 (Pracitronic - Germany). Acoustic stimulation was supplied through an external sound source: loudspeaker speakers (output power 40-80 W, frequency range 100-10000 Hz, maximum sound pressure level up to 100 dB) located at an angle of 45 ° at a distance of 1 meter from the external auditory canals. The study was carried out at frequencies of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz.
ASSR registration was carried out using the system of registration of evoked auditory potentials of the brain "SentieroAdvanced" (manufacturer "Pathmedicalsolution", Germany). The applied method of stimulation is multi-frequency ASSR. A frequency-specific Chirp stimulus (click) was used as the type of stimulus.
The installation of the electrodes was carried out according to the traditional scheme: the grounding electrode (forehead), the central one – (cheek), negative electrodes on the mastoid processes. Both tests were performed sequentially. First with the use of in-channel telephones, then with the supply of a stimulus in a free sound field, where the source of sound stimulation was a multimedia speaker system located at a distance of 1 meter from the external auditory canal of the subject.
The results of the study. The study was carried out under the same conditions, on the same equipment, by the same researcher. During the ASSR registration, the children were in a state of natural sleep. The initial level

of stimulation was 50 dB at the traditional carrier frequencies of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. Among the examined contingent of the 1st group, the ASSR response at a frequency of 500 Hz was received in 38 ears out of 40 studied, that is, the absence of recording was 5%, at all other frequencies, responses were received in all observed. The average response time, that is, the response stabilization time, was 2.10 minutes. When studying the ASSR thresholds in the same individuals with a stimulus in a free sound field, the values were distributed as follows: 500 Hz - 50 dB, 1000 Hz - 48 dB, 2000 Hz - 41 dB and 4000 Hz - 44 dB. The absence of response was noted at a frequency of 500 Hz in 15% of cases (6 ears). The average response time was 3.68 minutes, which means an increase of 1.58 minutes compared to the stimulus delivery using in-channel phones.
Of the examined contingent of the 2nd group, the ASSR response at a frequency of 500 Hz was received in 28 ears out of 40 studied, that is, the absence of recording was 70%, at a frequency of 1000 Hz, the response was received in 12 ears (30%), at a frequency of 2000 Hz and 4000 Hz, the response was not received at all. The average response time, that is, the response stabilization time, was 3.10 minutes. When studying the ASSR thresholds in the same individuals with a stimulus in a free sound field, the values were distributed as follows: 500 Hz - 90 dB, 1000 Hz - 95 dB, 2000 Hz - 100 dB and 4000 Hz - 110 dB. The absence of response was noted at a frequency of 500 Hz in 15% of cases (6 ears). The average response time was 4.58 minutes, which means an increase of 1.48 minutes compared to the supply of stimulus using in-channel phones.

121 - Automated auditory brainstem response - pilot screening program in three NICU units in Poland

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Background**:** Severe bilateral sensorineural hearing loss (> 50 dB) affects 1-3 in 1000 live births in the normal newborn population and 2-4 in 100 infants in the intensive care population. Early diagnosis and treatment of congenital and acquired hearing impairment in newborns is a key element for optimal speech development. Recent recommendations suggest implementation of AABR to newborn hearing screening, to identify the group of newborns at higher risk of hearing impairment. The aim of the study was to analyze the effectiveness of OAE and AABR used as screening tools for hearing impairment among infants.
Material and methods: The group of 880 infants (567 – with risk factors of hearing deficit; 313 – control group) was examined by means of both OAE and AABR before discharge from the hospital after birth. The risk factors of hearing deficit were recorded. Infants who failed the screening test and/or had risk factors were referred for further audiological evaluation.
Results**:** Out of 880 children 771 pass OAE test, 60 did not pass OAE test (38 bilaterally and 22 unilaterally) and 47 had no OAE test due to anatomical defects or respiratory support, 2 children died. The results of AABR were: PASS in 814 newborns, REFER 28 bilaterally and 38 unilaterally respectively. Nineteen children were diagnosed with hearing loss, 407 with normal hearing, 44 without final diagnosis and 95 lost to follow up. Among 19 children with hearing loss: 3 were diagnosed with mild bilateral conductive deficit <40 dB, 2 with moderate bilateral conductive hearing loss between 41 dB and 71 dB, 3 with mild unilateral conductive deficit <40 dB, 2 with moderate unilateral conductive hearing loss between 41 dB and 71 dB, 1 child was diagnosed with mild bilateral sensorineural hearing loss <40 dB, 3 were diagnosed with moderate bilateral sensorineural hearing loss between 41 dB and 71 dB, 2 with bilateral sensorineural hearing loss > 90 dB, 2 with mixed bilateral hearing loss <40 dB and 1 was diagnosed with mixed bilateral hearing loss between 41

dB and 71 dB. All newborns of the study group had at least one risk factor of hearing deficit – the most frequent were treatment in the intensive care unit (90%), mechanical ventilation (83.3%), and ototoxic treatment (75.1%). AABR exam was assessed by the staff as more difficult and time consuming to perform (mean time of the exam 6.9 min; SD 6.64) when compared to OAE.
Conclusions: The AABR method, recommended as gold standard for hearing screening in premature babies, is very useful in early diagnosis of hearing impairment. It allows for early identification of infants with hearing deficit as it examines the entire auditory pathway. However, it seems to be more difficult to perform when compared to OAE.
Keywords: AABR, newborn hearing screening, hearing loss, NICU

431 - Shielding apparatus for reduction of ABR artifact when using the B250 transducer
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Background Bone conduction (BC) stimulation in auditory brainstem response (ABR) investigations are needed to assess an objective hearing evaluation of patients who are suffering from conductive hearing loss. However, at low frequencies, large currents in the transducer (speaker) will generate magnetic fields causing artifacts being picked up by electroencephalogram (EEG) electrodes attached to the patient's head. For this reason, BC stimulation is rarely used for ABR measurements even though it has several advantages over air conduction (AC) stimulation. In particular, the artifact makes it difficult to use BC stimulated ABR for screening of newborn babies and young children with small heads as the transducer must be placed closed to the measuring electrodes. The artifact will also be more prominent in measurements of patients with severe hearing loss who need to be tested at high sound levels. Recently, a shielding apparatus for the BC transducer B250 was developed at the Chalmers University of Technology, Gothenburg, with the intention to reduce this artifact. Also, the inherent design of the balanced electromagnetic separation transducer in B250 is expected to partly reduce the artifact as compared to conventional variable reluctance type transducers like the B71. The aim of this study was to evaluate its shielding ability to reduce the electromagnetic artifact arising from the transducer during BC stimulated ABR.
Methods Measurements of the magnetic flux density surrounding the transducer was measured using a Lake Shore 425 Gaussmeter at a distance of 2.5 cm from the transducer center, both with and without shielding. Two different stimuli were evaluated; the transducer generating pure tones of 50 dB HL for the audiometric frequencies 250, 500, 750 and 1000 Hz; and when a constant input current of 100 mA_{RMS} was swept between 100 and 1000 Hz. Furthermore, the electrical properties of the shielding apparatus were evaluated by electrical impedance measurements.
Results and discussion At a fixed hearing level of 50 dB HL, the artifact was in average reduced by 51.5±1.2% for all four test frequencies with a maximum artifact observed at 500 Hz. It was discovered that B250 required less current at 250 Hz than at 500 Hz to generate the same hearing level due to its resonance peak at 250 Hz, resulting in lower artifact. At frequencies above 500 Hz, the artifact rapidly decayed below the noise floor. For the constant input current measurements, the maximum artifact was observed at 131 Hz and decayed with frequency. The average artifact reduction was calculated to 53.7±3.9% between 100 and 1000 Hz.
Conclusions The proposed shielding apparatus for the B250 is reducing the artifact by approximately 50%. Due to the inherent frequency response of the transducer, the artifact at 250 Hz will be lower than at 500 Hz for the same hearing level. In the next phase, different stimulation signals and ABR measurements will be investigated on healthy subjects as well as patients with conductive hearing loss to determine the clinical significance.
Keywords: Bone conduction, Auditory brainstem response, B250

INTERVENTION AND REHABILITATION STRATEGIES AND METHODS

426 - Defining client-centred outcomes to demonstrate success of hearing rehabilitation in the Australian Hearing Services Program
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Objectives: To date, there has been no consensus about which outcome measures should be used, how and when. Furthermore, most existing outcome measures have been developed without the involvement of consumers of hearing care. The principles of experience-based co-design suggest that health services, policymakers, and researchers should come together with clients to define what metrics should be used for their success. This study aimed to obtain a consensus on what outcome domains best reflect successful

hearing rehabilitation according to both Professionals who provide hearing care and Consumers of hearing services.
Methods**:** Two online Delphi processes were undertaken, one among Professionals involved in hearing services and one among Consumers of hearing services. In the first round, participants were asked to describe potentially relevant and important outcome domains for the assessment of hearing rehabilitation. In two subsequent rounds, respondents were asked to rate the importance of statements in relation to outcomes of successful hearing rehabilitation. The most important domains from both the professionals and the consumers were combined, and a consensus workshop of professionals and patient advocates agreed on the top four domains.
Results**:** Two sets of important outcome domains of hearing rehabilitation were developed. The outcome domains focused strongly on psychosocial outcomes of hearing services, rather than popularly used metrics such as use of devices and satisfaction with services. The top four ranked domains were: communication ability, personal relationships, and well-being, and social participation. In addition, there was consensus that an independent body develop and monitor a national outcomes database.
Conclusions**:** There was a strong recognition of the broader impacts of hearing difficulties, including impacts on family, social and community life. Many outcome domains do not have established and validated outcome measures that directly target these domains, and development of relevant outcome measures is required.

379 - Short term reliability of the Dutch Test for (Audio-) Visual Speech Perception on word and sentence level

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Introduction: Speech understanding is a complex bimodal process in which auditory as well as visual information play an important role. Especially in complex listening situations, for example in the presence of hearing impairment, visual information including speech reading, is an essential source of information. Speech reading is a complex skill which can be improved through training. In order to measure the effect of training, a validated and standardised test for (audio)-visual speech perception is needed. To the best of our knowledge, there is a lack of reliable, validated, and standardized (Dutch) measurement instruments to document visual speech perception in a structured way.
Therefore, a Dutch Test for (Audio-) Visual Speech Perception on word level (TAUVIS-words) was developed (Ceuleers et al., 2021). Subsequently, the TAUVIS was optimized and extended to sentence level (TAUVIS-sentences). Hence, the aim of the present study was to evaluate the short-term reliability of the TAUVIS-words and TAUVIS-sentences.
Methods and Results: The Dutch Test for (Audio-) Visual Speech Perception on word level (TAUVIS-words) and sentence level (TAUVIS-sentences) was constructed. The TAUVIS-words consists of 3 monosyllabic word lists and 3 polysyllabic word lists and the TAUVIS-sentences consists of 3 sentence lists. The lists are composed as equally as possible (word structure, distribution of visemes, familiarity with the word, visibility of the words) and the test procedure was standardised. Three lists provide the opportunity to examine speech understanding in the three modalities (i.e. auditory, visual, audio-visual modality). A study on test-retest reliability in a group of 40 normal-hearing adults and 8 adults with hearing loss is now being conducted (age between 18 and 70 years). Each participant is tested twice with a time interval of approximately 2 weeks. Data collection and analysis is ongoing and the results will be presented at the HEAL congress 2022.
Conclusion: This study presents the reliability of the TAUVIS. The authors expect better performances for the polysyllabic words compared to the monosyllabic words on the one hand, and better performances for sentences compared to words on the other hand. This can be related to the increased contextual information in respectively polysyllabic words and sentences. Furthermore, it can be expected that the visual condition will be more difficult for all participants, though the authors will investigate whether the performance in the visual condition may be better in the hearing-impaired group compared to the normal-hearing group. Last, in normal-hearing participants, equal performances are expected for the auditory and audio-visual conditions. In contrast, for the hearing-impaired group, better performances on the audio-visual condition compared to the auditory condition are expected, due to the combination of auditory and visual information. As such, the TAUVIS provides more insight into the speechreading skills of a person with a hearing-impairment as well as to what extent this person understands speech in the audio-visual modality. Based on the results of the reliability statistics pertaining to the TAUVIS outcomes, significant clinical changes in the performances on this test can

be determined, and further implemented in individual training programs in order to monitor, for example, effects of revalidation. Besides, this test can be used to evaluate the effect of training on speechreading.
Keywords: speechreading, audio-visual speech perception, auditory training

99 - Validation and cognitive contributions to a listening training paradigm
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More than 5% of the population has disabling hearing loss. Even more adults report difficulties with understanding speech in noise. Hearing aids manage sensory loss, but only (partially) solve problems in difficult listening situations. A complementary rehabilitation strategy can be (auditory and or cognitive) training. An increasing body of literature suggests that a critical factor in improving listening skills is the more active engagement of cognitive control processes (attention, working memory, inhibition and task switching).
We propose a listening training paradigm, where cognitive control processes are embedded within an auditory task. The paradigm is based on an English paradigm, developed by Dr. Henshaw (University of Nottingham, UK) and Dr. Heinrich (University of Manchester, UK), and involves a a discrimination task, where participants attend towards one of two speakers based on a written cue. The signal-to-noise ratio of concurrent speakers is varied adaptively.
This study aims at assessment of baseline performance in normal-hearing young and middle-aged adults for different listening scenarios, different maskers and procedural differences. By comparing results on the listening task with two non-auditory cognitive measures of inhibition and switching, we aim at gaining insights into the cognitive contributions of the listening task. Results of this study will be discussed at the meeting.
Funding body: C1-project C14/19/110, KULeuven.
Keywords: listening training, cognitive control, auditory skills

PATIENT PERSPECTIVE

89 - It's a family thing: Authentic ways to effectively involve communication partners in appointments
Cherilee Rutherford [(1)]
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Hearing loss should not be considered an individual problem: it is always shared and shaped by the environment and social context (Tjørnhøj-Thomsen & Philipsen, 2019). Hearing loss has a well documented impact on both the individual, as well as their families and communication partners. The impact of hearing loss on the family is acknowledged by the World Health Organisation as a third-party disability (2001). In spite of this, contemporary hearing care appointments do not routinely involve communication partners in an effective way. Third party disability is not typically measured or addressed in audiology consultations, even though tools and resources to this end are readily available.
Family members and communication partners should be included in the diagnostic and rehabilitative pathways, not only because of third party disability, but also because research indicates that their inclusion plays an important role in the help-seeking behavior of the person with hearing loss (Meyer et al, 2014), and in the success that they have later in using hearing aid technology (Hickson et al, 2014). Research also suggests that audiologists are in a unique position to facilitate these person- and family-centered practices that are valued by professionals and consumers alike. Family members are interested to participate in and share their perspectives and experiences regarding their loved ones' hearing care. In spite of this, audiologists typically do not invite them to speak, would revert the conversation back to the patient after a brief interaction, and then tend to leave the communication partner "shut out" of the conversation between the patient and audiologist (Ekberg, 2015).
The Ida Institute have developed ethnographic documentaries to help clinicians explore the impact and value of family member perspectives to the traditional one-to-one view on the patient-clinician relationship. Active reflection, supported by the ethnographic method, can be a powerful tool to facilitate change and increase awareness and sensitivity to the challenge of effective and authentic, family-centered hearing care. Ida, in collaboration with hearing care professionals from around the world, have also developed a number of clinical tools and resources to enable the inclusion of communication partners in the hearing care journey. This session will provide hands-on experience for clinicians to work with families and communication partners before,

during, and after their appointments using a combination of telecare and face-to-face resources. It will provide practical strategies and peer feedback to work with families in a collaborative way that supports the development of healthy and productive therapeutic relationships.

Learning Outcomes:

At the end of this session, participants will be able to:

1. Describe the role of family members and communication partners during hearing rehabilitation
2. Evaluate how communication partners are currently involved in routine appointments
3. Create fresh and modern ways of involving family members and communication partners in an authentic, person-centered manner.

90 - My Hearing Explained – Describing hearing test results in person-centered ways

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Ida Institute, Audiology, Naerum, Denmark [1] - Kent Hearing, Audiology, Kings Hill, United Kingdom [2]

People with hearing loss report that they often struggle to understand the results of their hearing assessment, to confidently make decisions about next steps in care, and to relate outcomes and their implications to family and friends. This session will explore how a hearing care professional may best communicate a person's hearing status and its implications in order to enable easy understanding and informed decision-making during hearing rehabilitation.

Informed decision making, shared goal setting, and involvement of family and friends are three fundamental components of person-centered care (PCC). These require easy and effective communication between a hearing care professional, their patient, and their patient's key communication partners. However, there are often barriers to effective communication between these stakeholders, resulting in people with hearing loss and their communication partners struggling to understand the results of their hearing assessment, the implications for their lives, and the recommendations of a hearing care professional.

The Ida Institute conducted a year-long innovation process to explore and understand gaps in communication during the appointment and patient understanding of the audiogram and hearing test results. The process involved surveys, focus groups, interviews, and a multi-national and interdisciplinary workshop attended by academics, hearing care professionals, people with hearing loss, and communication partners.

Through this process we have come to understand the gaps in communication and understanding during the appointment, and have explored possible solutions relevant to each stakeholder (the hearing care professional, the person with hearing loss, and their key communication partners). The IDA Institute has co-created a new resource for improving communication and understanding of hearing test results. In this talk participants will explore these topics through ethnographic videos, conversations, and an opportunity to try out Ida resources for improving communication and understanding in the appointment. We will also share some early clinical impressions and experiences with clients and professionals who have implemented the use of the tool in their practice.

Learner Outcomes

Upon completion of this session, the participant will be able to…

-Describe key challenges of communicating hearing test results and implications to patients with hearing loss

-Implement changes in their practice to make communication about hearing care diagnostics and implications more person-centered, using Ida resources

-Participants will be able to describe patient preferences and needs about understanding their hearing abilities

219 - Journey in and from the silence

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EFHOH, European Federation of Hard of Hearing People, Houten, Netherlands [1]

Gradual transition to the complete hearing loss, accompanied anxieties and feelings of powerlessness that appears when even the basic communication is almost impossible. Feelings of loneliness and non-understanding, feelings of fear and loss. And then the return. Slow. Gradual. Discovery and learning. Re-entrance to the world that is known and close to you. The world, which you enjoy and feel free, safe, and equal. The world of sounds. And you cherish and acknowledge the happiness that you acquired with the ability to hear and understand again. The fact that the quality of your life has changed, it has increased. You recognize the great possibilities of combining technology and your body, but at the same time you also know the other world. World of silence. You encounter it daily. You know that deep black silence. Disturbed only by the irritating tinnitus. That is why you only cherish more the state you are in now; the opportunity to hear and understand others again. However, you still acknowledge the need for adaptions of the environment and people around you. That you, besides the implant, also require support. What can you do about it?

345 - Hearing Aids Reimbursement systems in Europe- can we do better supporting people with hearing loss? – "we are not walking audiograms!"

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Recently "functionality and hearing loss" has gained attention of those working in hearing care field and seeking to improve hearing care provision. Affordability of hearing access is only first step in provision of the hearing care. The hearing care professionals also realise, life is very noisy and often challenging for hard of hearing people, even after they are fitted with their hearing aids or cochlear implants.
This is positive trend in hearing care profession, and we should encourage more discussions about it. Some people can adapt and manage their hearing loss reasonably well, but others cannot, they need support and reasonable adjustments to help them all to thrive. Do audiologists discuss different accessibility aspects with their clients? How well are they preparing clients and patients for the world after receiving the hearing aids or CI and the confusing information they receive? Unfortunately, accessibility aspects of using hearing technologies are rarely part of the rehabilitation and counselling, not sure why?
EFHOH will discuss why use of the WHO ICF is supported by patient representatives and how using ICF leads to person centred care. People presenting with hearing loss should not be seen as walking audiograms, rather as partners working together to achieve best outcomes.
In addition, in 2018 the European Federation of Hard of Hearing People (EFHOH) published the report on the state of current provision of hearing aids and reimbursement systems to bring better transparency and information for service users across the EU.
EFHOH will present our advocacy work related to providing affordable hearing care and services, improving quality of hearing care services, complementing World Report on Hearing Recommendations. We will share findings from the report in 2018 and the most recent report which will be shared during the conference.
Discussion: How can alliance between hearing care providers, audiologists and users' representatives bring improved access to hearing aids and quality of hearing care?

415 - Accessible communication campaign on prevention, well-being and health for deaf people. Results and future prospects

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Ente Nazionale Sordi, the Italian Deaf Association, promotes the rights and acts for the social inclusion of people with hearing disabilities in every area of daily life, with particular attention to health care, conceived in a global sense as attention to individual, emotional and physical well-being. This dimension originates from italian Constitution which provides in art. 32 "protection of health as a fundamental right of the individual and collective interest" and the most recent definitions of the World Health Organization which defines health "A condition no longer of absence of disease but of complete physical, mental and social well-being ".
Deafness is a serious disability with serious consequences but often underestimated in their social, relational impact and access to every area of daily life; without adequate information and accessibility services deaf people are often relegated to the margins of society.
In terms of health, prevention, nutrition and other issues related to personal well-being, communication barriers constitute a dramatic obstacle to correct information on correct lifestyles and make them particularly vulnerable to disinformation and fake news.
Furthermore, health institutions are often not prepared to properly interact with the a deaf person.
This is why the project "How do you feel? Inclusive campaign for prevention and health support for deaf people "(https://cometisenti.ens.it/) was born, with the aim of launching a series of actions to make the main issues relating to prevention, treatment of health and well-being in general.
Among the various organized activities:
- about 60 online seminars - made accessible through subtitling and translation into sign language - attended by over 1000 deaf people. The seminars were held in collaboration with the Istituto Superiore di Sanità - Higher Institute of Health, Telefono Azzurro, the Department of Clinical and Molecular Medicine of the La Sapienza University of Rome and other excellent partners and concerned health and prevention, the style of life, nutrition, environment, ailments and diseases.

- an awareness-raising course aimed at staff working in health facilities aimed at facilitating the adoption of reception and communication strategies with deaf people.
- digital content on issues relating to health and prevention to give continuity to the project and contribute to the removal of barriers.

In this report we intend to share the results achieved and the methodologies adopted in order to network energies and good practices and increasingly favor accessibility for deaf people.

396 - Advocacy action by family and user groups to influence global public health policies on hearing care

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Hearing Care has traditionally had a low priority for public health funding and the impact of hearing loss in adulthood or childhood is under-recognized and rarely understood. This is despite the fact that hearing loss in adults is the major cause of Years Lived with Disability over 70 and hearing loss in children has a profound effect on their learning and life chances. With growing numbers of adults with hearing loss and growing recognition of the impact of adult deafness including the association with cognitive decline and dementia, there is a growing body of evidence that addressing hearing loss needs to be a central part of health policy. The World Report on Hearing (WHO, 2021) makes the case strongly for people-centered Ear and Hearing Care to be integrated into national health care planning. The case for this is enhanced by the growing evidence of the impact of today's hearing and communication technologies and the proven social and economic benefits.

One example to be addressed is the gap between those who receive cochlear implants (CI) and those who could benefit; globally only 1 in 20 who could benefit receive an implant, despite of the evidence of effectiveness, including cost-effectiveness.

A global consultation was undertaken with CI and hearing aid (HA) users, families and professionals. Interviews undertaken with 32 individuals from 22 countries, and survey of 63 individuals from 28 countries on their views on the barriers to CI and the role of advocacy. Content analysis of responses identified and prioritised the major themes:

- The barriers to access to CI: a lack of awareness of both the impact of hearing loss and of the effectiveness of CI, leading to lack of referrals and insufficient funding. The barriers appear to be much greater for adults than for children and these barriers appear likely to increase as a result of COVID-19
- A strong belief in the value of advocacy work and the role of the user/family groups
- Agreement about the key strengths of advocacy work: prioritised diversity, increased grass roots action in time of societal change, powerful messages, decision makers listening to user groups.
- Agreement about the challenges for advocacy work: managing diversity, time, resources, mixed messages, conflict between groups, need for advocacy training.
- Strong enthusiasm for advocacy action: advocacy/user/family groups working together, leveraging the user voice globally for increased CI access and long-term management.
- Suggestions for new ways of working: a network, platform, coordination, a loose structure to facilitate joined up activity.
- Consensus on key goals and objectives of a global advocacy initiative, and suggestions about possible structure.
- An interactive digital platform to be the hub of activity; to share resources, activities, inspire action, research and evidence …..and what not to do:"reinvent the wheel".

The respondents gave 52 global examples of the impact of advocacy work in changing hearing provison. However, initiatives are under-resourced and fragmented.

The work of advocacy groups and professionals and industry working together can facilitate real shifts in policy at the national and international level, but requires coordination for impact. A global advocacy network for CI users and their families was proposed and implemented: CIICA, the CI International Community of Action. In less than a year, CIICA has 75 organisations and 350 individual members from 45 countries; the Steering Group has a majority of CI users or family members and the majority of individual members are CI users and family members.

This paper will present examples where advocacy and user groups have worked together, what has been learned, the resources found useful to support such activity and their impact.

With the impact of the pandemic on health service resourcing and hearing services in particular CI services, it is even more essential to influence today's policymakers and decision-makers to ensure that hearing well is

central to future investment in health services. User and family groups are key to successful advocacy and need to be empowered and given the tools for change to be successful.

2 - Social support and social connectedness - how tinnitus support groups work

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Background Hearing loss and tinnitus are chronic conditions which require adaptation. In the UK support groups such as Tinnitus Groups are a widely adopted support mechanism for people with tinnitus.
Objectives: Our objectives were to determine the active ingredients of tinnitus support groups. Specifically, to identify mechanisms through which groups provide support for individuals living with tinnitus.
Design: We adopted a pluralist and iterative approach informed by the realist evaluation method.
Methods
We conducted ethnographic data generation at tinnitus support groups involving observations (*n*=160), focus groups (n=130) and individual interviews (*n*=20). Inductive analyses were conducted following the constant comparison method of grounded theory. We then interrogated the inductive themes to identify evidence of Contexts, Mechanisms and Outcomes. We then produced a model which was tested in a survey of tinnitus group members (*n*=65). The survey data were used to test the model, which was then refined to produce a model of tinnitus support groups.
Results: We identify that tinnitus groups can facilitate social connectedness between group members. This experience appears to build resilience to tinnitus related distress. Groups also have a role in building a sense of control related to knowledge and information sharing. We additionally identify risks in not accessing social support in a group environment.
Conclusions: Our findings contribute to the growing understanding of the power of social connectedness as building shared social identity.

476 - Priorities in hearing – Towards a common goal

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Background: In the field of hearing research, almost all topics and questions have relevance to health and society. However, it can be challenging to provide clear evidence of the wider value ("impact") and importance of grant proposals. Funders themselves also face a challenge in making strategic decisions about areas to fund. Citable evidence of expert consensus on the value of specific topics and questions can be of value to those seeking and providing funding.
We believe that there is currently no contemporary source which describes the priorities in the field of hearing research. Such a resource, if drawn from a representative and broad enough sample of the population of experts, could increase the competitiveness of hearing research projects seeking funding, and hopefully increase the capacity of the field overall.
Our objective is to consult the international field of hearing researchers about what they think the priorities in hearing research should be for the next 5-10 years, with a view to developing and publishing an agreed set of priorities.
Methods**:** We generated an initial pilot set of priorities by sending an open response questionnaire to 40 UK experts of Professorial status). There were 18 responses. These responses were thematic analysed by an expert in qualitative analysis. The categorisation of themes was then presented to subject experts in order to check content validity and refine theme categorisation. Based on this pilot, we generated a new structured questionnaire and repeated the thematic analysis process, this time seeking opinions from senior experts internationally (Dec 21/Jan22). Based on these themes closed questions will be generated for a questionnaire which is intended to canvas the views of all in the international field of hearing research (Spring 2022). The questionnaire will ask respondents to rate the importance of different themes and sub-themes, the tractability of making significant progress in the themes and sub-themes, whether themes and sub-themes were currently receiving the appropriate amount of attention.

Results**:** An analysis of these data so far, will be presented at the meeting. A link to this questionnaire will be made available at the presentation, inviting attendees to contribute, and build the evidence.
Conclusion**:** The present work aims to benefit all hearing researchers by providing a large-scale canvas of opinion on the state of hearing research and current priorities. The goal is to provide clarity and evidence of mandate to grant funding bodies, and to increase competitiveness in a challenging funding landscape.

FAMILY PERSPECTIVES

46 - Mild matters: insights into the conundrums of managing mild congenital hearing loss (parent perspective)

Jing Jing Lin [(1)] - Valerie Sung [(1)] - Lynn Gillam [(2)] - Libby Smith [(1)] - Peter Carew [(1)] - Alison King [(3)] - Teresa Ching [(4)]
Murdoch Children's Research Institute, Population Health, Melbourne, Australia [(1)] - The Royal Children's Hospital, Children's Bioethics Centre, Melbourne, Australia [(2)] - Hearing Australia, Paediatric services, Melbourne, Australia [(3)] - National Acoustic Laboratories, Rehabilitation Procedures research, Sydney, Australia [(4)]

Background: Significant advances in the management of hearing loss have led to earlier diagnosis and intervention. Hearing aids are now increasingly being prescribed in young children with mild hearing loss. However, there is limited evidence for their benefit in this group, leading to confusion amongst clinicians and parents regarding management. We also do not know if there are any detrimental effects from early hearing aid fitting.
Aims**:** This study aims to explore parental experiences related to early management of mild bilateral sensorineural hearing loss, including management options offered and, positive or negative impact of hearing aids.
Method**:** Using a qualitative approach, we conducted semi-structured interviews with caregivers of children < 3 years old with mild bilateral sensorineural hearing loss. Data collection continued until saturation of themes was reached. Interviews were analysed using inductive content analysis.
Results**:** We interviewed twelve parents. There was a wide variation in the management strategies they reported. Perceived positive impacts related to hearing aids included: parents feeling empowered and relieved once hearing aids were fitted; perceived improvement in the child's hearing response and facilitation of parenting and behaviour management. Perceived negative impacts related to hearing aids included: difficulties with compliance resulting in frustration and guilt; damage or loss of equipment; no improvement in the child's hearing response; pain and discomfort; parental discord; altered quality of natural sound; worry about bullying/stigma in the future. Where hearing aids were offered and not fitted, there was significant ongoing uncertainty and the family carried the burden of their decision.
Conclusions**:** There was wide variation of practice in the early management of mild bilateral hearing loss, based on caregiver report. We identified positive and negative impacts of hearing aid fitting and not fitting. These results have informed a pilot randomised trial to ultimately guide management.

384 - "Hope for the best, prepare for the worst": Exploring Parent Support Needs during the Newborn Hearing Diagnosis Pathway

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Background: Universal Newborn Hearing Screening facilitates early detection of hearing loss in newborns. Previous literature suggests parents find the pathway to their child's hearing loss diagnosis overwhelming and stressful. Existing investigations into parent support needs revealed parents require accurate and up to date information during the hearing diagnosis pathway, coordinated service delivery, as well as support from other families who have lived experience. In recognition of specific support needs among parents, support services have been established by some Universal Newborn Hearing Screening programs, like that of the Royal Children's Hospital's Victorian Infant Hearing Screening Program. The Early Support Service team offers support to parents by guiding them through the diagnosis pathway, answering any questions and providing parents with both written and verbal information. Yet, limited research has been conducted to understand how

to best support parents in the context of a well-established Universal Newborn Hearing Screening program. This project aims to retrospectively explore parental support needs along the newborn hearing diagnosis pathway. This will enable the Victorian Infant Hearing Screening program to understand the needs of parents to enrich the service and inform clinical practice.
Method: A qualitative study to explore parental support needs following the newborn hearing screen until enrolment into early intervention services. Semi-structured interviews were conducted with parents whose newborn was diagnosed with a bilateral moderate-profound sensorineural hearing loss within three to six months post confirmed diagnosis. Data were analysed using inductive content analysis.
Results: Thirteen parents of ten children were interviewed. Parents described high satisfaction with the support they received and found proactive contact from the service to be valuable. Some parents did not feel prepared for a diagnosis of hearing loss, having been reassured that transient causes such as middle ear fluid caused the hearing screen result. In addition to the support received, one family suggested that the father should also receive an initial phone call from the support service. The delivery of information via multiple methods, such as email and verbally over the phone, was beneficial for parents when trying to process the diagnosis. Examples of information parents found helpful post-diagnosis included resources about early intervention services, resources for extended family and practical tips about how to manage hearing loss. There was a mixed response to the helpfulness of parent mentor support, with some parents finding it very useful while others found it too confronting in the early days. However, social media platforms, such as Facebook support groups, were highlighted as advantageous for informally connecting to other parents with similar experiences. Additional support requirements described by some parents included access to therapeutic psychological support to help adjust to their child's hearing loss diagnosis. Finally, the impact of the COVID-19 pandemic on the support service delivery highlighted the importance of face-to-face contact.
Conclusion: These findings provide insight into how the Victorian Infant Hearing Screening Program is supporting parents and may help inform how this service can be further enriched for families along the hearing diagnosis pathway. The findings from this study have implications for practice including modifying the delivery of information following the newborn hearing screen and a referral pathway for therapeutic counselling. Additionally, other Universal Newborn Hearing Screening Programs can learn from the provision of an embedded support service. Ultimately, when the support provided was able to adapt to the individualised needs of the family, parents felt more empowered in their abilities to help their child achieve their full potential.
Key Words: Newborn Hearing Screen, Parent Perspective, Support Needs

152 - Parent-reported quality of life outcomes in children with hearing loss diagnosed under different systems of congenital hearing loss detection

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Introduction. Universal Newborn Hearing Screening (UNHS) aims to detect hearing loss early and improve outcomes for impacted children and families. The existing literature indicates children with bilateral hearing loss of moderate or greater degrees have better health-related Quality of Life (HRQoL) if detected earlier rather than later. However, there is limited information on whether HRQoL is improved with earlier detection for children with milder losses and those with unilateral loss.
Aims**.** In a population-based study of children detected with any type and degree of permanent hearing loss under a UNHS system, we (1) describe the parent-reported HRQoL of children by laterality and severity of hearing loss, comparing to children without hearing loss from the same population, and (2) explore any differences between parent-reported HRQoL in these children to those detected under the previous risk factor detection system.
Methods**.** Cross-sectional study of 237 children with congenital hearing loss aged 5-7 years born in Victoria, Australia. All children with hearing loss were participants in at least one of two state-wide population-level studies: one study comprising UNHS-detected children with any degree and laterality of loss (n=175), the other comprising children detected under a risk factor referral system with bilateral aided hearing loss (n=62). HRQoL was assessed using the parent-report version of the Pediatric Quality of Life Inventory (PedsQL).
Results**.** When the UNHS group participants were categorised into having unilateral hearing loss, or bilateral hearing loss where the better ear was in the mild, moderate, severe or profound range, a differential pattern of parent-reported HRQoL was observed; children with severe bilateral loss were reported as having the poorest HRQoL, and children with unilateral loss showed a trend towards poorer HRQoL with lesser degree of hearing loss. Of those with bilateral aided losses (UNHS n=89, risk factor n=62), the mean HRQoL total score for children detected under the UNHS system was not substantially different to those detected under the risk factor referral system (UNHS mean HRQoL 72.8, SD 18.5; Risk factor mean HRQoL 75.5, SD 17.9,

p=0.37). This was despite the UNHS group average age at diagnosis being earlier than that of the risk factor group. When compared with similar-age children without hearing loss, quality of life scores were poorer for UNHS-detected children with hearing loss (n=175) in this population cohort.
Conclusions**.** These results suggest that earlier diagnosis is not associated with improved HRQoL, and laterality and severity of hearing loss do not have a linear relationship with HRQoL among school-age children. Further exploration of factors known to influence HRQoL are required within population-level studies of children with hearing loss, including those with unilateral hearing losses.
Keywords: child; congenital hearing loss; health-related quality of life; pediatric

277 - Do we consider the importance of the first 1000 days of life?
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Early detection of the signs of a different disorder or even better identifying those at risk of a specific kind of pathology is a goal that sees the interest of Healthcare professionals, managers who manage dedicated resources and users who will benefit from more effective treatments converging and less invasive. The communication and language disorders in the developmental age are well suited to the logic of screening and early diagnosis, but apart from a few laudable exceptions, the norm remains the diagnosis of pathologies now evident for which a more onerous rehabilitative effort will be necessary with results often less satisfactory.
Starting from the awareness of the maximum neuroplasticity, the knowledge that the health of the individual starts from the womb, the events of transformation of the life of the person as a couple and with the birth of the child in the family. Given that in the life cycle of the couple, becoming parents affects early childhood, we propose the pilot project "The importance of the first 1000 days" aimed at identifying early signs of delays in motor and linguistic development in collaboration with free pediatricians of choice and with kindergartens. The goal is a path of awareness and education of new parents on how to deal with the neuro-psycho-motor development of the child in the first years of life.
Aware that their children's emotional and communication needs are important as their nutritional needs, parents will be able to take advantage of dedicated "spaces" managed by speech therapists and psychologists. Through observation, follow-up and consultancy, the fundamental evolutionary stages for the development of communication and language can be monitored with serenity, attention and competence to be shared with the reference pediatrician.
This type of approach allows you to support the couple who turns into a family, guide them and help them in their first parenting experience. In addition, it allows us to deal with slight delays that can be recovered quickly, but also to identify any major diseases early by promptly initiating the diagnostic process and the educational-rehabilitation intervention.

441 - Impacts of the COVID-19 pandemic on the wellbeing of deaf and hard of hearing children and their parents
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Introduction: During 2020, children in Victoria, Australia were exposed to a variety of government-imposed suppresion strategies to slow the spread of the virus. Understanding the social, economic, and mental health experiences of deaf and hard of hearing (DHH) children and their parents during the COVID-19 pandemic is crucial to provide appropriate services and supports. We aimed to describe child, parent and family experiences, before and during the COVID-19 pandemic for children with all degrees and types of permanent hearing loss.
Methods**:** The Victorian Childhood Hearing Impairment Longitudinal Databank (VicCHILD) is a statewide population-based databank of children with permanent hearing loss in Victoria, Australia since 2012. In May-September 2020, 806 participant VicCHILD parents were invited to complete an online survey about their family's experience of the pandemic. 497 (62%) parents completed at least some of the survey. Measures were drawn from the CoRonavIruS Health Impact Survey (CRISIS v3.0), spanning several domains

(demographics, health, family/living situation, COVID-19 health/exposure status, life changes due to COVID-19 crisis, daily behaviours, emotions/worries, media use). We reported data using descriptive statistics, with continuous variables as mean (standard deviations) and categorical variables as proportions. We used paired t-tests to compare available data at two timepoints (before and during pandemic) to assess change.
Results**:** Survey respondents were predominately mothers (94%), located within Australia (98%). Almost all (90%) had a partner living with them. Survey participants had a neighbourhood disadvantage index slightly higher than the Victorian average (mean: 1013.5, SD: 65.1 compared to Victorian average mean: 1000, SD: 100); but were similar on all other demographic measures. Approximately 19% of participants lived in a remote area and most had completed high school (89%), with a high number also holding a tertiary qualification (59%). Most spoke English at home (79%), although there were a significant proportion who spoke a language other than English (21%). Children (43% female) were aged 6.5 years (SD: 4.0 years) at the time of data collection. Most had bilateral sensorineural hearing loss (65%) with a range of severity from mild (24%), moderate (29%), severe (17%) to profound (22%). Thirty-nine children had auditory neuropathy.
Parent's reported that both their own wellbeing (mean parent emotions/worries CRISIS summary score changed from 1.05 pre- pandemic to 1.43 during the pandemic, P<0.0001) and their child's wellbeing (mean child emotion/worries CRISIS summary score changed from 0.76 pre-pandemic to 1.10 during the pandemic using a 5-point Likert scale between 0 and 4, P<0.0001) worsened during the pandemic compared to before, with similar shifts to poorer wellbeing reported across all levels of hearing loss type and severity.
Some families were experiencing significant adversity during the pandemic with 10% of parents reporting significant financial problems were created by the pandemic, 13% concerned about the stability of their housing situation, 15% reporting their financial situation as just getting by or finding it quite/very difficult and 75% reporting difficulty paying at least one bill during the pandemic.
Just under half of parents (43%) reported that their child had trouble with learning from home due to their hearing loss at least some of the time. Nonetheless, the majority (83%) reported their child was engaged with and enjoying learning from home at least some of the time. Parent experiences of their children learning from home were less favourable. Most parents (81%) reported feeling stressed or overwhelmed and finding it difficult tending to their child's home learning while doing paid work or domestic duties at least some of the time.
Discussion**:** Average wellbeing was poorer for parents and their DHH children during the pandemic compared to pre-pandemic levels. These effects may be partially attributable to the large social and economic changes reported by families during the pandemic. While parents commonly found it stressful and difficult to complete their paid work or domestic duties while supervising their children's home learning, most children were engaged with their learning at least some of the time. Our study illustrates the importance of addressing the indirect social and mental health impacts of COVID19 in planning for government funding supports and services.
Keywords: wellbeing, deaf and hard of hearing, COVID-19, child

438 - Accessing hearing-health services for deaf and hard-of-hearing children during the COVID-19 pandemic: parent and child perspectives

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Introduction: During 2020, children in Victoria, Australia were exposed to a variety of government-imposed suppresion strategies to slow the spread of the virus. The social, economic, and mental health experiences of deaf and hard of hearing children and their parents during the COVID-19 pandemic is not well understood but understanding their experience is crucial for providing appropriate services and support are in place. We aimed to describe hearing-health service use during the COVID-19 pandemic in deaf/hard-of-hearing children.
Methods: The Victorian Childhood Hearing Impairment Longitudinal Databank (VicCHILD) is a population-based databank of children born in Victoria, Australia. It commenced collecting data from parents of children with hearing loss in 2012. Between May-September 2020, 806 parents of children enrolled in VicCHILD were invited to complete an online survey about their family's experience of the pandemic. 497 (62% of invited) parents completed at least some of the online survey. Of these, 336 (42%) provided comments about the impact of COVID-19 on child use and access to services. We summarised quantitative data using descriptive statistics, and analysed free-text responses using inductive and deductive reasoning with NVIVO software and a pre-determined codebook.

Results: 711 of 1152 (62%) services used by families were accessed via telehealth (telephone/ video). Parents reported their child found telehealth appointments more difficult (347, 52%) and worse quality (363, 56%) compared to face-to-face. These difficulties were more evident in preschool than school-age children. Several challenges in service access (delay or difficulty in access, anxiety related to COVID-19, preference or requirement for face-to-face, reduced quality of telehealth sessions) and benefits of telehealth (continuity of care, convenience and increased or ease of access) were identified.
Discussion: Many deaf/hard-of-hearing children accessed hearing-health services via telehealth during the COVID-19 pandemic. Parents reported many challenges with service access, as well as barriers and benefits of telehealth use. It is important to consider these factors in hearing-health service provision for deaf/hard-of-hearing children.
Keywords: COVID-19, telehealth, hearing impairment, qualitative analysis, quantitative analysis

1 - Parental decision making for unilateral hearing loss
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Aim: This study's objective was to explore parental information needs for decision making for children with unilateral hearing loss.
Methods: A qualitative study was utilised with a grounded theory approach. Twenty-one families across the United Kingdom were interviewed in their homes. The ages of the children with unilateral loss ranged from zero to sixteen years old. Five interviews consisted of both parents being present. All interviews were conducted in English.
Findings: Parents were keen to reframe their notion of 'normal' for their family as appropriate for their child. This was a shifting balance between parental concern and their child's autonomy with decision making involvement. Factors that fed into this process were sources of information, the perceived level of 'Deafness' and support from healthcare professionals. Parents were active in seeking information and guidance to help support their child across their educational and social development. Decisions ranged from the use of hearing amplification, access to additional support and continued monitoring of their child's needs.
Discussion: The findings from this study correspond to that of the wider literature. Information sources were lacking in providing sufficient information to families. Autonomy and child choice were important for parents from other healthcare fields also.
Conclusion: Parental decision making is an iterative process dependent on their child's needs. Information was sought from healthcare and associated professionals, support networks and social media. Parents were keen to promote child autonomy as they grow older.

FAMILY EMPOWERMENT (1)

401 - Shared reading habits in children with normal hearing and children with hearing loss (0-3 years): results of a fact-finding survey
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ASST Sette Laghi, Audiovestibology, Varese, Italy [(1)] - Università degli Studi di Pavia, -, Pavia, Italy [(2)]

Aim: In literature we can find evidence on the positive role that shared reading plays on the development and growth of children either emotionally, linguistically and cognitively.
The aim of the work is to investigate the differences in shared reading habits between parents and children with normal hearing and parents and children with hearing loss in the age group 0 - 3 years.
Methods: A questionnaire was formulated and structured especially for this study. The questionnaire was administered to parents of normal hearing children in nursery schools in the province of Pavia (IT) and parents of deaf children enrolled in the Audiovestibology's audiological-rehabilitation programme (ASST Sette Laghi Varese). At the end of the data collection, we performed a statistical analysis using the Chi-squared test and we considered a level of significance of 5% ($p < 0.05$) .
Results: No statistically significant differences emerged between the two groups. In particular, there was no difference regarding the shared reading habits (whether they read aloud to their child, from what age they started to read to their son, how many hours per week, which books they mainly choose for their child).
Discussion: These findings suggest that parents of deaf children enrolled in the Audiovestibology's audiological-rehabilitation programme (ASST Sette Laghi Varese) have shared reading habits comparable to

those of normal hearing children. It is essential for language development that children with hearing loss participate in shared book reading activities with their parents or caregivers.
Key words: shared reading, language development, adult-child language interaction, hearing loss

111 - What matters to you? Person centered care when transitioning families from universal newborn hearing screening programs to audiology services
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Each year, the Victorian Infant Hearing Screening Program (VIHSP) refers over 600 infants to diagnostic audiology. As hearing is essential for speech and language development, an efficient referral to a paediatric audiologist is usually a key priority for the VIHSP Area Manager (AM). During the consultation with a family, the AM is normally focused on providing information supporting this referral and answering questions regarding the hearing screening pathway.
But asking families 'What matters to you?' – A central tenet of person-centred care (National Health and Safety standards (NHSQ)) – can become an afterthought.
Opportunities exist to strengthen person centred care practices by asking the family what matters to them much earlier in the process. Hearing screening programs have the opportunity to partner with families to share and act on this information.
We propose the following strategy for increasing person-centred care in this process:
1. 'Person centred questions' framework for Universal Newborn Hearing Screening (UNHS) staff that acknowledge families may still be establishing what matters to them in this stage of their infant's care
2. Ensuring access to Person Centred Care training for UNHS staff and audiologists
3. Standardised means of communicating person centred information between UNHS and Audiologists
4. Strategies to ensure the necessary investment from health teams to act on this information.

This paper will provide discussion and reflection on strengthening the way UNHS engages at the point of referral to audiology – a critical step in moving to more person centred care model.

224 - The CARE Project Family Retreat National Initiative: New Opportunities for Family Engagement
Johnnie Sexton [1] - Patti Martin [1]
The CARE Project, Executive Director, Raleigh, NC, United States [1]

This presentation will provide information, outcomes and ideas for replication from a three-year project in the United States designed to improve/broaden family engagement opportunities for families with children who are deaf/hard of hearing with a primary focus on the emotional journey.
The 3-year CARE Project Family Retreat National Initiative resulted in completion of family weekend retreats in ten states in the U.S., focusing on parental engagement as a critical component in the journey for families of children who are Deaf/Hard of Hearing. With an emphasis on providing emotional support and empowerment, each retreat was developed collaboratively at the state level and served as a model project within that specific Maternal and Child Health Region. The CARE Project (TCP) Family Retreat demonstrated not only the value of an immersion experience for families, but provided an opportunity to further evaluate the outcomes associated with this type of strategy for family support. Establishing an ongoing peer group of similar others post-retreat was a desired outcome and efforts to maintain connectivity were both formal and informal, including state specific events, national EHDI conferences and parent support group gatherings, as well as multiple strategies to develop virtual communities. Additionally, the component of providing graduate student pre-professional experience was incorporated and a service learning opportunity for graduate students in Audiology and Speech-Language Pathology resulted in exposure to a critical mass of very young infants and children who are D/HH outside of the clinical setting. Outcomes from Years I and 2 were incorporated to fine tune implementation steps for Year 3, expand on strategies for individualization by each specific state, and maximize efforts to advocate for opportunities to connect families at the systems level.
Ongoing efforts to build upon the literature related to the "why" of family support was accomplished through use of the pre- and post-survey tool developed by Nannette Nicholson, Ph.D., specifically for use with The CARE Project Family Weekend Retreats. It is based on the revised theoretical model for parent-to-parent support for parents of children who are deaf or hard of hearing proposed in Henderson, Johnson and Moodie (2016). The questionnaire consists of 17 items across four broad categories: (a) Family Well-Being (i.e., family connectedness, interaction, adaptation and confidence), (b) Child Well-Being (i.e., advocacy, confidence, goals, socialization) (c) Knowledge (i.e., sharing, finding accurate information, confidence in decision-making, interaction with other parents) and (d) Empowerment (i.e., confidence in communication, ability to adapt,

feeling empowered, confidence in decision-making, and participation). Pre-and post-retreat surveys are the same with the addition of four satisfaction items on the post-retreat survey.
Without exception, host states over the 3 years of the grant asked for ideas to fund further retreats or similar experiences due to the feedback about impact received from the participating families. Furthermore, ongoing inquiries about how to host TCP routinely validate the impact of this model of family support as evidenced by successful efforts from several host states to secure funding through their respective state level agencies. Additionally, several states not selected as host states pursued outside funding based on feedback from host states and retreats occurred in a number of locations.
The outcomes of the family retreat experiences were consistently positive across all constructs for both families and volunteers and offers an innovative, replicable model of family support.

109 - Anxiety level in parents of children with hearing impairment of preschool and early school age
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University of Belgrade, Faculty of special education and rehabilitation, Department of special education and rehabilitation of Deaf and Hard of hearing persons, Belgrade, Serbia [(1)]

Parents have a crucial role in child's wellbeing. Parents of a child with disability often cope with the feeling of hopelessness, fear and uncertainty, which could induce a great deal of anxiety. The level of anxiety depends on many factors. After facing the diagnosis of deafness, the parents encounter multitude of choices regarding amplification, communication mode and rehabilitation options for their child. Various obstacles and new situations, such as joining kindergarten or enrolling in school can induce enormous anxiety in parents of children with hearing impairment.
The aim of this study was to estimate anxiety level in parents of the deaf and hard of hearing preschool and early school-age children. The goal was to discover the influence of the wide spectrum of factors, such as: parental gender, age, education, family structure, age of onset of hearing loss (HL) in child, etiology, model of amplification, rehabilitation, level of communication skills and additional disabilities on the parental anxiety level.
The anxiety scale was presented separately to mothers and fathers of the deaf and hard of hearing children. Forty-five parents were included in this study. The Beck anxiety inventory has been used. It is a Likert-type self-report assessment scale including 21-items rated from 0 to 3 points. Increased total score indicates higher level of anxiety experienced by an individual.
Results have shown that families with more than one child with hearing impairment and/or child who have multiple disabilities and lower language skills, experience greater level of anxiety. There was no significant impact of parental age and education, age of onset HL, etiology, model of amplification, rehabilitation on amount of anxiety that parents felt. However, mothers were significantly more anxious then fathers.
In families with hearing impaired children parental anxiety is frequently met and it may be affected by different factors and vary over time. Preschool and early school age is especially critical phase for children with HL, so that the parents are experiencing extreme anxiety at that time. It is therefore necessary to assess the parental anxiety level and provide adequate psychological support and counseling. The parents represent an important link between child, speech therapist and schoolteacher, so that overcoming anxiety in parents is essential for successful inclusion of child with hearing impairment in the new environment.
Key words: parents' anxiety, Beck anxiety inventory, deaf and hard of hearing, preschool, school

FAMILY EMPOWERMENT (2)

504 - To tell or not to tell? The stigma experiences of adults with hearing impairment and their families
Barbra Timmer [(1)] - Louise Hickson [(2)] - Katie Ekberg [(1)] - Nerina Scarinci [(1)] - Carly Meyer [(3)] - Monique Waite [(1)] - Mansoureh Nickbakht [(1)]
The University of Queensland, School of Health and Rehabilitation Sciences, Brisbane, Australia [(1)] - The University of Queensland, Faculty of Health and Behavioural Sciences, Brisbane, Australia [(2)] - University College London, Behavioural Science Policy Research Unit, London, United Kingdom [(3)]

People with hearing difficulties regularly have to decide to tell or not tell others that they have a hearing problem, uncertain about how others might react. Wearing hearing aids often means that the disclosure may be outside their control as others see the visible sign of the hearing problem. These feelings of stigma occur

because of societal values and threaten the identity of the person with hearing impairment and his or her loved ones. Furthermore, stigma has been implicated as a barrier to people seeking help for their hearing impairment and wearing hearing devices.

In this multidisciplinary research project using a sequential, exploratory mixed methods design, we investigated how stigma is experienced by adults with hearing impairment and their families, how they manage it in everyday life, and how these experiences relate to the decision to try hearing aids and to wear them in the long-term.

In the first phase of the research, data from 20 dyads of adults with hearing impairment (mean age 69.4 years, 17 female, 11 hearing aid wearers) and their nominated family members (mean age 63.9 years, 16 female) was collected. Data collection included a combination of 1) a range of validated, self-report questionnaires exploring hearing impairment and stigma, 2) conversation analysis of video-recorded conversations in daily life between the adult with hearing impairment and their family members, 3) Ecological Momentary Assessment with the adults with hearing impairment, and 4) qualitative semi-structured interviews with adults with hearing impairment and family members, individually and together. Additionally, in phase 1 we interviewed 25 hearing care professionals (mean clinical experience 10.7 years, 19 female) about their understanding of how stigma affects adult clients and their family members.

The findings from phase 1 were then mapped to the Major and O'Brien (2005) identity-threat model of stigma and revealed that stigma is a complex, social process experienced differently by adults with hearing impairment and their family members. Stigma associated with hearing loss and hearing aids was evident and resulted in delayed hearing help-seeking, as well as hearing aid uptake and use.

In the second phase, we surveyed 331 adults with hearing impairment (mean age 66.2 years, 149 female) and 313 family members of adults with hearing impairment (mean age 48.8 years, 247 female) in Australia, the UK and US to understand stigma and its impact on the uptake of hearing services more broadly. The findings from phase 1 informed the survey questions which were administered online.

The findings from phase 2 revealed that adults with hearing impairment and family members associate hearing loss and hearing aids in similar patterns. While both groups were generally positive about modern hearing aids, family members of adults with hearing impairment were more positive about hearing aids than adults with hearing impairment. The topics of humour emerged as a theme in both phases of this study and should be explored further.

The presentation will summarise the findings from both phase 1 and 2. It will highlight the differences found between the stigma experiences of adults with hearing impairment and family members, and the perspectives of hearing care professionals. Lastly the presentation will provide the clinical implications from this international study and how hearing care professionals could influence their clients' stigma experiences by changing the narrative they use in clinical interactions.

Keywords: Hearing impairment, hearing aids, stigma, family

371 - Family Empowerment through Digital Storytelling

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No Limits for Deaf Children and Families, Education, Los Angeles, United States [1]

Research supports the importance of parent involvement as a predictor of success for the communication and language development of children with hearing loss (Yoshinaga-Itana, 2003). More than 90% of children with hearing loss are born to hearing parents, yet most families have never even met a deaf person let alone possess knowledge of hearing loss and itsassociated challenges. It can be a daunting and lonely process. For economically disadvantaged families with minimal to no resources, it can often feel unbearable. My presentation will outline the fundamental tools of family empowerment, as well as highlight methods to unite families and communities through digital media and story sharing. The presentation will feature the outcomes of the acclaimed theatrical documentary, Silent NO MORE (with a book of the same name), which has been performed at Carnegie Hall and throughout the United States. According to a study by Stanford University, stories are up to 22times more memorable than facts alone (Aaker, 2017). Silent NO MORE demonstrates the power of storytelling by featuring the real-life hardships and successes of growing up with a hearing loss. These are not actors, but rather people with hearing loss residing in the local community. The stories by hearing siblings, parents, and educators provide a comprehensive personal experience about how deafness has impacted their lives, allowing families to relate to and learn from one another. Surveys distributed after each performance highlighted significant outcomes. The surveys showed that parents found the stories inspirational, educational, emotional, and informative. Byvideotaping these honest, true-life stories (which are stored in an easily accessed digital library),educators can help parents of newly diagnosed children learn to advocate for their child's futureand find a human connection to the often-overwhelming medical diagnosis of hearing loss. The personal stories from adults with hearing loss are particularly powerful, as they not only provide role models for children with hearing loss, but also a way forward for the entire family. Based on a 2013 study by Rogers and Young, introducing families to a diverse range of deaf rolemodels has been instrumental to making families feel reassured and thereby becoming more positive and confident about their child's deafness and future. As parents, educators, deaf adults,and siblings share their perspectives, parents can assess their own lives and gain insight about how to best care for their child with a hearing loss. Data indicates that 80 percent of internet users own a smartphone (Smart Insights), Facebook hasmore than 1.66 billion monthly smartphone users (DMR), and there are 4.92 billion mobile internet users globally (We Are Social, 2017). Educators can capitalize on this incredible access to technology by working with clients to capture their stories on a smartphone or tablet, without having to drive to an educational center. Thus, parents from remote locations or who have few resources especially benefit. They can watch the stories or create their own video from home. These stories empower communities throughout the world via websites, YouTube, social media,and other media outlets. Family advocacy through digital technology can capture, educate, and enliven one's own community and communities around the world by bringing role models and other familiestogether so no one ever feels they are alone on this often-unexpected life journey.

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356 - The accuracy of parental suspicion of hearing loss in children

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Background Parental suspicion of hearing impairment in their children is generally inaccurate. Parents tend to underestimate hearing problems in their children. The aim of the study was to assess the accuracy of parental suspicion of hearing loss in their children.
Material and Methods This was a population-based, epidemiological study conducted in elementary schools in villages and small towns in Poland. The study sample was 64,750 children aged 6-13 years old. The children underwent hearing screening with pure-tone audiometry. The parents answered a question about hearing problems in their children. The outcome parameters were sensitivity, specificity, and predictive value of parental perception of hearing problems in their children. Parental suspicion of hearing problems was assessed by a questionnaire. Pure-tone air-conduction hearing thresholds were obtained from 0.5 to 8 kHz. Hearing loss was defined as a pure-tone average higher than 20 dB in one or both ears in at least one of the three following pure-tone averages: four-frequency pure-tone average, high-frequency pure-tone average, and low-frequency pure-tone average.
Results Positive results of hearing screening were obtained in 16.3% of children. Hearing loss was detected in 6025 children (9.3%), of whom 1074 (17.8%) were correctly perceived by parents as having hearing problems. The degree of hearing loss was a significant factor which influenced the sensitivity of parental suspicion of HL in their children. Sensitivity of detecting hearing loss by parents reached about 20% for mild hearing loss and above 31% for moderate or worse hearing loss.
Conclusion Parents underestimate hearing problems in their children, but they are more able to accurately detect hearing loss if it involves speech-related frequencies and is at least a moderate hearing loss or bilateral loss.

255 - The parents reaction to the communication of the result in the first level of the OAEs: Importance of the doctor-patient dyad

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Neonatal auditory screening in the last thirty years has become one of the main factors leading to the early diagnosis of deafness and audio-linguistic rehabilitation of children with congenital and / or perinatal hearing impairment. As is known, auditory screening is now routinely performed in maternity wards most of the time from the second to the fifth day of a new-born's life and subsequently through a further check-up, where the new-born has not passed the test, within 30 days of life.
The object of this research was to evaluate how the doctor-patient dyad might affect the taking of positive result on the first level of neonatal hearing screening and affect the state of anxiety in parents.
Doctors are aware that the parents are in an anxiety state, especially those who have a first baby. The way how the information is transmitted to a parent in the first days after the birth of the baby have a crucial importance for a good communication to them of the results of the first visits and examinations, in our case of the new-born hearing screening.
The study was conducted in a neonatology and obstetrician ward. The level of anxiety was measured by using a STAY – Y questionnaire. The questionnaire was distributed to a parent after the communication of the results of neonatal auditory screening. In this study we included 120 parents (mothers and fathers) who were divided into two groups: experimental and control. The experimental group consisted of the parents whose children have not passed the first step of the level of the neonatal auditory screening. The control group was composed from the parents whose babies passed the new-born hearing screening test.
Parental reactions were essentially different, but regardless of the type of reaction, they are substantially negative in the case of unexpected or bad results, even if only "temporary" ones such as high bilirubin at birth. In our case, it often happens that parents who have received unexpected or bad news about the result of the first level neonatal hearing screening do not return to the follow-up check within 30 days because, according

to them, after careful observation to at home, it seems that the child has a normal reaction to auditory stimuli or because they refuse to accept the information communicated.
In this research, we examined the parent reaction after hearing assessment at birth and the importance of how this information was communicated in the doctor-patient dyad. As has been shown, in the protocol of neonatal auditory screening programs, and not only, sometimes little importance is given to the communication of such delicate information to new parents (sometimes it also happens that parents only receive a written report on the matter). It is therefore essential to have attention to the communication method, in addition to explaining to the family the importance and need for further monitoring of the new-born as regards auditory screening and that support is provided. If it seems necessary, it could be important to include the professionals of the sector, psychologist for example, in the very first period after the birth of the son.

383 - Supporting Families of Children with Hearing Loss: What Parents Want from their Audiologist
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Young children with hearing loss and their families will engage in a long-term relationship with their clinical audiologist. While audiologists aim to support families and their child's use of hearing technology, research has shown that parents require additional guidance in the areas of social skill development, friendship, and community inclusion. In this presentation, findings from a mixed methods study examining the audiologist-parent relationship will be shared. Because the audiology clinic is an ideal environment to promote self-determination, this presentation will also discuss how a SDT management approach could be used to support families of children with hearing loss.

Posters

P.01 – EARLY IDENTIFICATION OF HEARING LOSS

507 - National Universal Newborn Hearing Screening Program in Italy Survey 2018

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Background The aims of this paper were to present data on the implementation and coverage of Universal Neonatal Hearing programmes and to evaluate the organization and management of these healthcare procedures in Italy.
Materials and methods Data were collected through a nationwide survey conducted during the period January-March, 2018. The questionnaire was sent to all the 409 public maternity hospitals (public hospitals and private maternity hospitals active within the National Health System),
Results Overall 427,365 newborns out of 448,386 (95.3%) received the hearing screening test (first level) in 391 out of the 409 maternity hospitals (95.5%), with a national mean referral rate of 3.63% (SD ± 4.58).
A statistically significant increase ($p<0.034$) of newborns sent to audiological examination was found in maternity hospitals with Neonatal Intensive Care Unit (NICU) with "TEOAE only" protocol (9.32% SD ± 7.57), compared to those with "TEOAE/AABR" (3.0% SD ± 3.29).
Conclusions The coverage of the neonatal hearing screening program had reached the required goal of 95%, while the performance indicators (referral rate in NICU) still fell below the international benchmark.
There is a need to address the identified causes through more suitable protocols to identify characteristics and risk factors for infants NICU. Currently, early monitoring and routine intervention CMV screening is not yet performed in our country. An alternative approach is performed, for all infants who do not pass their newborn hearing screening at first level to CMV DNA testing in urine by PCR within the first 3 weeks of life.
Implementation of a centralized data tracking system for each child, will improve health system efficiency.
Keywords: Newborn; hearing loss; hearing screening;

117 - The Russian universal newborn hearing screening program: 10 years' experience

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The universal newborn hearing screening program in Russia (Russian UNHSP) has been performed nationally since 2008 with full implementation by 2010. There are about 1,7 million live births in Russia annually. The transient evoked otoacoustic emissions (TEOAE) testing is conducted in birth facilities to all babies with subsequent outpatient re-screening for referrals or initial outpatient TEOAE testing for non-hospital births within first month of life. Full audiological assessment is performed for babies failed the screening as well as for high-risk babies. The recommended age for audiological ascertainment is 3 months of life for well babies according to 2007 JCIH (Joint Committee on Infant Hearing) Position statement.
The aim of the study is to assess the advantages and disadvantages of Russian UNHSP throughout 10 years passed.
According to Ministry of Health monitoring data based on regional reports, the Russian UNHSP had achieved the recommended benchmarks by 2012 with subsequent improvement. For the year 2017, the coverage was 99% for hospital births and 96% for all newborns, the referral rate was 1,8%. The follow-up rate has grown to 92% with interregional range 45-100%. As a result of Russian UNHSP the proportion of babies with congenital mild and moderate hearing loss has increased to 22% in comparison with 7% during the high-risk newborn hearing screening performance. The average age of cochlear implantation in children performed in the National Research Center for Audiology and Hearing Rehabilitation has dropped from 3,4 to 1,9 years of life.
The age of diagnostics had never been monitored before that could be concerned as a great disadvantage due to the absence of a national screening electronic system. The results of hearing screening in the 2012 birth cohort revealed that only 30% of babies had received the audiologic diagnostic before 3 months of life. The ongoing National Project "Public Health" is aimed to implement electronic medical cards that could be used to collect the screening results and timing data accurately and to increase the efficacy of the program.

To raise awareness of timely diagnosis and to share responsibility between health care providers and baby's parents or caregivers the informed consent with the screening result form was introduced.
Another weakness of the Russian UNHSP is a lack of pediatrician audiologists at the diagnostic stage especially in the low population density areas and low insurance taxes for audiology assessment reimbursement. The National Medical Association of Audiologists established in 2017 aims to work out on these issues.

420 - Results of the Newborn Hearing Screening Pilot Program

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Diagnosis of hearing loss in children at such an early age is only possible with audiological screening of newborns - a mass examination of hearing using quick and simple methods in order to identify children with suspected hearing impairments. There are 2 approaches to identifying newborns with hearing impairments: examination of hearing in children with risk factors for hearing loss; examination of hearing in all newborns.
According to statistics, there are 1-2 babies with profound hearing impairments per 1000 newborns. For comparison, the incidence of phenylketonuria, the detection of which has long been introduced in maternity hospitals in Uzbekistan, averages 1 case per 10,000 newborns.
The incidence of hearing loss increases significantly among newborns in intensive care units, and is 30-40 children per 1000 newborns. Among them, a significant proportion are premature babies with a birth weight of less than 2000 G, hearing loss in this group is about 15 children per 1000 newborns.
Since 2014, Uzbekistan has begun to introduce selective hearing screening for newborns with risk factors for hearing loss in central maternity hospitals in the regions of Uzbekistan. Screening coverage was 8.3%. The average age of children undergoing cochlear implantation surgery in this period was 4.3 years.
Since 2020, a pilot program of universal screening with tracking control of screening has been introduced in the city of Tashkent. The results for the period of 8 months of the pilot project showed - 55% screening coverage. A positive screening response - hearing is normal in 67.5% of the examined, screening error - 16.9% of children, screening failed on one side (one ear) - 13.1% of the examined, screening failed on both sides (both ears) - 7.4% of children, re-screening was carried out at the Center for Pediatrics (complete examination of hearing): the frequency of hearing pathology was 1.03 per 1000 newborns (0.103%). In 2021, the age of children for cochlear implantation surgery was 1.8 years.
The introduction of a universal hearing screening program in all regions will make it possible to cover the maximum number of newborns with operations under the age of 1-1.5 years with a reduction in the duration of rehabilitation measures. The universal screening program should take into account technical issues: service centers of the manufacturer of audiological screening devices in the regions of the country, increase the number of screening devices per maternity complex, taking into account the number of births in a given region, education and training of audiologists in the regions.
Keywords:hearing loss, newborn, screening program

350 - Prevalence of hearing loss among Polish school-age children from rural areas – results of hearing screening program in the sample of 67 416 children

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Background Hearing loss in children is a relevant health issue, both for its prevalence and for its physical, emotional and social consequences. Our aim was to estimate the national prevalence of hearing loss in children from rural areas in Poland.

Material and Methods The study was conducted in the general, pediatric, nonclinical population of school-age children from rural areas in Poland. It was a population-based, epidemiological study. The participants were 67416 children (32630 girls and 34786 boys) aged from 6 to 13 years old (M=8.65; SD=2.54). Pure-tone air-conduction hearing threshold were obtained at 0.5-8 kHz. Hearing loss was defined as a pure-tone average higher than 20 dB in one or both ears in at least one of the following pure-tone average: four-frequency pure-tone average (FFPTA), high-frequency pure-tone average (HFPTA) and low-frequency pure-tone average (LFPTA).
Results The rate of positive results of hearing screening was 16.4% and it was significantly higher in younger children than in older children. Mild hearing loss was more frequently than moderate or worse hearing loss. The children more often experienced unilateral than bilateral hearing loss.
Conclusion This study reveals that hearing problems are common in this population, especially among younger children. It shows a strong need for systematic monitoring of hearing status among children and increasing awareness of parents and educators of the significance of hearing loss, including unilateral and mild hearing loss. Further studies conducted among children in urban areas are needed to compare the prevalence of hearing loss in children from various environments.

18 - Is pass rate in newborn hearing screening with otoacoustic emissions affected by gender, feeding or maternal smoking?

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Neonatal hearing screening by means of transient evoked otoacoustic emission (TEOAE) is widely accepted. Some studies have related how maternal smoking can be harmful for newborn's cochlear function. The aim of this study was to investigate the relationship between maternal smoking and TEOAE newborn hearing screening results. Data were retrospectively collected from healthy vaginally delivered newborns of gestational age > 37 weeks and body weight > 2.5 Kg, at Francesc de Borja Hospital maternity ward in Gandia (Spain). Maternal smoking history was compared with the pass rate to TEOAE performed within the first 48 hrs. of life. Results: the study group included 12,871 newborns. In this group, no significant relation between maternal smoking and TEOAE pass rates was observed ($p<0.853$). As there were significant differences in pass rate depending on gender (female better, $p<0.0001$) and feeding of newborn (breastfeeding better, $p<0.0001$) we analyzed these subgroups separately and also found no differences related to smoking history. Conclusion: Gender and feeding are significant factors that affect pass rate to TEOAE screening. Maternal smoking effect in newborn hearing screening with TEOAE is not significant. Further studies are needed.

160 - Self-controlled pure tone audiometry for hearing screening for adults with intellectual disability

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Objective: Hearing disorders are more frequent and occur earlier in life in persons with intellectual disability. However, regular hearing checks are seldom performed even in institutionalized persons. During the Health programm of the Special Olympics wintergames, an easy-to-use, small hand-held device for self-controlled hearing threshold determination for children was tested on intellectual disabled athletes.
Methods: The Multiple-Choice-Auditory-Graphical-Interactive-Check (MAGIC) (Sentiero, Path Medical Solutions, Germany) was performed in 72 intellectual disabled athletes (age 28 ± 12 years, 50 men, 22 women). It is an image-based self-controlled pure tone audiometry with a touch screen. Both ears were consecutively tested on an automated at 2 and 4kHz as proposed by the SO Hearing Screening procedure. The testing was supported by volunteers who had a 1h training on the method before. The results are compared to a conventional pure-tone audiometry (PTA) performed by an experienced audiologist. Thresholds of at least 25dB are taken as normal hearing.
Results: In 64 athletes (89%), MAGIC could be performed with support of volunteers. PTA was performed in 69 persons (96%). OAE screening could be performed in 59 volunteers (82%). 8 athletes refused to use MAGIC or were not able to follow the instructions. PTA and MAGIC were consistent in 61 right ears (85%) and

57 left ears (79%). Consistency was given when PTA threshold was better than 30dB or threshold was worse than 25 dB in the higher frequencies. For MAGIC sensitivity was 85% and specificity was 92%.
Conclusion: For most athletes of the Special Olympics, MAGIC could be applied for hearing testing showing good consistency to conventional pure tone audiometry. The measurements can be supported by non-specialized persons and therefore could also be applied in a non-medical surrounding such as institutions to enable for a wide use of regular hearing testing on adults with intellectual disability.
Keywords: Hearing disorder; Hearing screening; Early detection of hearing loss; Intellectual disability

457 - Hearing loss and disabilities: an epidemiological survey in the Emilia-Romagna region
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Congenital hearing loss is one of the most common sensory disorders, affecting one out of 1-3000 newborns. The diagnosis and management of pediatric hearing loss has changed significantly in the past 30 years, since the introduction of newborn hearing screening (NHS) and the developing of newly generation hearing aids and cochear implants.
The most common causes of permanent congenital sensorineural and mixed hearing loss are structural abnormalities of the temporal bones (30%-40%), and genetic causes (50%) More than 400 syndromes associated to hearing loss and other symptoms have been described, corresponding to 30% of cases of hereditary hearing loss. Moreover, it has been reported that 30%–40% of children currently receiving cochlear implants also have other comorbidities. Children with hearing impairment can also present developmental disabilities such as autism Spectrum Disorderor Attention-Deficit/Hyperactivity Disorder.
Emilia Romagna is a region allocated in the north of Italy, with about 4.400.000 inhabitants. Since January 2012, all neonates routinely undergo hearing testing according to the screening program with a two stage Transitory Evoked Otoacoustic Emission (TEOAE) protocol (GPG 498\2011). This legal act has also implemented the NHS and intervention programs, contextually establishing a Hearing Disabilities Regional Table (HDRT). The HDRT has technical co-ordination functions, plan support, maintenance and network facilitation of professionals and operating units involved in the pathway (neonatology, audiology \ORL, childhood and adolescence neuropsychiatry). NHS covers all newborns of the region, and further audiological tests are indicated for those who fail the secondary screen and those identified as high-risk groups. This study is based on a regional survey and aims to measure the prevalence of hearing loss with associated disabilities in the infant population
Key words: hearing loss, children, newborn hearing screening

355 - Central auditory processing disorder (CAPD)- hearing screening programme in groups of children in school-age
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Background CAPD (Central Auditory Processing Disorders) are defined as abnormality with processing of auditory information at higher level of central nervous system. It can impact on linguistic abilities, education and social aspect. The research conducted in World Hearing Center in group of 60 children showed that earlier detection of CAPD is connected with obtained clinical outcomes. The best results after therapy with using SPPS-Ska (Stimulation of Polymodal Sensory Perception- Skarzynski method), were observed in range aged 7-10 years old of children in comparison with group of children above 11 years old. Hearing screening programme enables an earlier detection and prevents of negative impact on child development. Use of e-Health tools and innovative solution such as: Sense Examination Platform ® enable to conduct a hearing screening in a large- scale. The aim of this study was to evaluate the usefulness of the DDT (Dichotic Digits Test) using in order detect CAPD in school-age children during hearing screening.
Material & Method During hearing screening programme in Poland, examinations were conducted in groups of 76,429 children. Approximately 45,5% were 7 years old and 44,9 % were 12 y.o., using Sense Examination Platform ®. For CAPD's screening was used a Polish version of DDT, which comprising 20 pairs of digits from

1-9. In group of 7 years old's children was performed in the divided attention mode, in which children were asked to repeat all heard digits. In group of 12 years old, was performed both in divided attention and in focused attention for each ear separately. Parents also asked to fill out a questionnaire. In order to eliminate a hearing problems, pure tone audiometry was conducted.
Results Analysis of results showed that approximately 11,3% in group of 7 years old children was positive result in DDT test and 11,3% for 12-years- olds in a divided attention mode. In the focused attention mode the comparable result for 12 years old children was 9,7%. It needs to be highlighted that positive DDT result was correlated with other disorders such as dyslexia and social problems. In children with incorrect DDT results, parents indicated significantly more hearing problems, attention deficit problems, difficulties in social contact with peers.
Conclusions Analysis of the results of DDT tests as well and questionnaire data showed that hearing difficulties, speech dysfunctions and education problems occur significantly more often in group of children with incorrect result which can indicate of problems with auditory processing. Combining an audiological method (DDT) and psychometric tools make it possible to fast and earlier detect hearing problems in a large-scale in school environment and prevent to develop difficulties in daily life. Also, it enables to plan an adequate therapy.

138 - Sound-in-noise screening: Towards an internationally applicable school-entry hearing screening test

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Hearing loss is one of the most common congenital impairments, occurring in 1 to 3 per 1000 newborns. The incidence of acquired hearing loss during childhood is not exactly known but is said to be as high as congenital hearing impairments. Unidentified hearing loss leads to higher risk for speech, language and learning impairments as well as the risk for low social communicative abilities. Therefore, in 2012, the European Federation of Audiology Societies formally recommended the implementation of preschool and school-age hearing screening, in addition to the systematic hearing screening of newborns to detect those children and prevent secondary impairments. However, hearing screening in young children, for example at school entry, requires an innovative approach as practical test conditions, acoustics and stimuli, and the applicability in very young children are challenging. Not all countries have resources for the development, validation and implementation of school age hearing screening. Therefore, the key to the success is the choice of an appropriate screening method, that is cost-effective, quick and inexpensive, highly reliable and valid, and can be used internationally, without adaptations.
At this moment, research is being conducted to develop a language independent sound-in-noise test, the Sound Ear Check (SEC). This is an automated adaptive self-test on tablet based on recognition of masked ecological sounds. The SEC has already been evaluated in adults, and shows promising results. A reference curve with a steep slope of 18%/dB was obtained, resulting in a test with a high measurement precision of 1 dB. Significant correlations with both pure tone thresholds (r = 0.70) and the Digit Triplet Test (r = 0.79) speech-in-noise test were found in adults. Sensitivity and specificity values of about 80% were obtained.
The current follow-up study aims to investigate the feasibility and validity of the test in young school-age children, at the age of school-entry (5-6 years). In collaboration with study partners from different European countries, an international study was conducted on the applicability of the test as a language- and culture independent school entry hearing screening test

58 - Screening Questions for Hearing Loss in Adults Living with HIV

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There is increasing research on adults living with human immunodeficiency virus (HIV) (ALHIV) being more at risk for hearing loss than adults living without HIV (ALwoHIV). Specifically, from hearing data from the Multicenter AIDS Cohort Study (MACS) and the Women's Interagency HIV Study (WIHS), after adjusting for age, sex, race, and noise exposure, ALHIV had significantly poorer low-frequency and high-frequency hearing than ALwoHIV in the better ear. Given our previous work above, it might be useful to implement a

hearing screening question as part of routine health care for ALHIV. As a result, the purpose of this study was to evaluate specific questions from the Hearing and Balance Questionnaire utilized in MACS/WIHS to determine whether a single question or combined questions would identify hearing loss in ALHIV warranting audiometric evaluation.
The closed-set questions of interest were:
1. “Is your hearing: Excellent; Good; A little trouble hearing; Moderate trouble; A lot of trouble; or Are you deaf?”
2. “Is your hearing in your WORSE ear: Excellent; Good; A little trouble hearing; Moderate trouble; A lot of trouble; or Are you deaf?”
3. “Have you ever had ringing, roaring, or buzzing in your ears or head, also known as Tinnitus?” (Yes/No)
4. If Yes, “Does this ringing, roaring, or buzzing usually last for 5 minutes or longer?” (Yes/No)
Pure-tone air-conduction threshold data were obtained, binaurally, for octave frequencies from 0.25 through 8 kHz, including 3 and 6 kHz using a clinical audiometer and supra-aural earphones. For the statistical analyses, the questionnaire data were collapsed into dichotomous outcomes. The separate outcomes for Questions 1 and 2 were: a. excellent and good were combined; and b. a little trouble hearing, moderate trouble, a lot of trouble, and are you deaf were combined. The tinnitus questions were combined into: a. those who reported No to Question 3 and Yes to Question 3, but No to Question 4; and b. Yes to Question 3 and Yes to Question 4. Pure-tone averages (PTA) for each ear were calculated using 0.5, 1, 2, and 4 kHz thresholds and a worse ear PTA was defined as the higher PTA between the ears. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were subsequently determined for each dichotomous question outcome with worse ear PTA.
There were 221 ALHIV (105 women and 117 men) with questionnaire and pure-tone threshold data. For Questions 1 and 2, specificities were 83.0% and 83.9%, respectively, while NPVs were slightly higher, both questions were 86.9%, for ALHIV. Sensitivities for Questions 1 and 2 were lower, 51.1% and 48.8%, respectively, with PPVs of 43.4% and 42.9%. The combined tinnitus questions had a specificity of 89.8% and a NPV of 83.6% for ALHIV along with a lower sensitivity of 31.1% and a PPV of 43.8%.
To date, this is the first study to evaluate the sensitivity, specificity, NPV, and PPV of hearing-related questions and hearing loss in ALHIV. The questions, however, in the current study had higher specificities and NPVs; in other words, they were stronger at identifying ALHIV with normal hearing rather than those with hearing loss. Sensitivities and PPVs were 50% or lower, and given that ALHIV are more at risk for hearing loss, these questions were less than ideal. Further investigation is needed on more detailed questions, such as “Do you feel you have a hearing loss?” or “Has an audiologist or physician told you that you have a hearing loss?” to identify questions with higher screening efficiency for detecting hearing loss risk among ALHIV.
Key words: adults; HIV; hearing; screening

479 - Suppression-evoked otoacoustic emissions in infants with congenital syphilis: preliminary results

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Introduction: Pregnant women infected with *treponema pallidum*, inadequately treated or untreated, transmit transplacentally or in some cases by direct contact with syphilitic lesion in the birth canal syphilis to the fetus. About 1% of pregnant women attending antenatal consultations had positive tests for syphilis, approximately in 2016, 1 million pregnant women were infected (WHO, 2018). Untreated syphilis in pregnancy continues to result in substantial numbers of adverse birth outcomes, including stillbirth, neonatal death, prematurity, low birth weight, and other congenital diseases such as hearing loss. Congenital syphilis is a risk indicator for hearing loss (*Joint Commitee on Infant Hearing*, 2007, 2019) and is associated with late and progressive onset, reaching the VIII cranial pair. In Brazil, the Ministry of Health (2017, 2019) recommends audiological follow-up every six months until two years of age. Transient Otoacoustic Emissions Evoked (TOAE) with contralateral noise has been presented as a method that allows to evaluate the integrity of the brainstem, analyzing the active activities of the outer hair cells to the superior olivary complex investigating the function of the olivocochlear efferent system. Objective: To analyze the transient suppression otoacoustic emissions responses in infants with treated congenital syphilis. Method: Cross-sectional and observational study approved by the Institution's Research Ethics Committee (No. 3,360,661). Sixty-nine babies up to two months old were evaluated. thirteen babies with bilateral or unilateral nonlinear TOAE absence, 13 babies who did not complete the nonlinear TOAE. We also excluded three babies with absence of linear bilateral TOAE, five babies who did not complete the linear TOAE without contralateral noise. Thus, the sample of this study consisted of 35 babies divided into two groups, G1 with 20 babies with treated congenital syphilis and G2 of 15 babies with no risk indicator for hearing loss. All ears responses of the sample babies presented absolute presence and latency of waves I, III and V and interpeaks I-III, III-V and IV within expected at 80 dB nNa and

presence of wave V at 30 dB nNA in Brainstem Evoked Response Auditory (BERA) click, nonlinear and linear noise-free TOAE with signal / noise ratio greater than 3 dB at 1KHz and 1.5KHz and 6 dB at other frequencies ≥ at least three frequencies. The evaluation of the efferent pathway was performed comparing the TOAE responses linear stimulus 80msec without contralateral noise, 1024 sweeps, intensity of 60 dBNPS and speed of 21.10/s with TOAE with contralateral noise, the noise presented was white noise, with 400ms suppressor time, 10ms ISI and 60 dBNPS intensity. Suppression was calculated by subtracting the level of TEOAE response without noise from the level of TOAE response with contralateral noise. Values greater than one indicated the presence of TOAE suppression. Analyzes for comparison between groups were performed using the Mann-Whitney test for measures of suppression, TOAE general response level and response level by frequency band without noise and with noise per ear. A significance level of 5% was adopted, $p<0.05$. Results: The response levels by frequency band of noiseless TOAE were higher for 1 and 1.5 kHz and with contralateral noise in all frequency bands to the right for the G2. Both groups had higher response levels for the left ear in the silent condition and the right ear with contralateral noise, not showing statistical significance. Both groups had low occurrence of suppression, with G1 29.4% and G2 23.1%. Conclusion: Preliminary analysis of data from this research so far shows that babies using the efferent pathway do not differ from babies without risk indicators. These findings will be confirmed with the increase in the sample.

478 - Auditory brainstem response in infants with congenital syphilis: preliminary results

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Syphilis is an infectious disease caused by the bacteria Treponema pallidum. The transmission of the etiological agent occurs through sexual contact, in acquired syphilis, or vertically, from mother to child, in congenital syphilis. Vertical transmission occurs from an untreated or inadequately treated pregnant woman to the fetus through the placenta, at any time during pregnancy, or through the birth canal, if there is an active lesion. One of the clinical manifestations of late congenital syphilis is sensorineural hearing loss, with the eighth cranial nerve being affected. Audiological follow-up is recommended during the first two years of the infected child's life. In audiological diagnosis in the evaluation of infants younger than six months, the auditory brainstem test (ABR) is considered the gold standard test, in addition to providing information on the neurophysiological integrity of the auditory pathway from the vestibulocochlear nerve to the brainstem. Objective: to investigate the integrity of the retrocochlear auditory pathway through the responses obtained by the click-ABR in exposed infants and infants with congenital syphilis. Method: The sample consisted of infants aged 0 to 3 months born and recruited in public maternity hospitals, which constituted three groups: group 1 (G1), consisting of four infants exposed to congenital syphilis; group 2 (G2) of 23 infants with congenital syphilis; and the control group (G3) of 19 infants without other risk indicators. All infants included in the study had Transient Stimulus Evoked Otoacoustic Emissions (TOAE) present bilaterally. The click stimulus ABR was performed at an intensity of 80 dB nHL, 2048 stimuli were presented in rarefied polarity, duration of 100μs and presentation speed of 27.7/s. The rate of rejections and artifacts did not exceed 10%, the analysis window was 15ms and the filter was 30-3000 Hz. To perform the ABR, the infants were in a state of natural sleep in the mother's lap. Surface electrodes were placed on the infants, with the active electrode placed on the forehead, the reference electrode on the mastoid (M1, M2) of the ear to be tested, another reference electrode on the contralateral mastoid and the ground electrode on the forehead. The impedance of the electrodes did not exceed 2KΩ and between the electrodes 5KΩ. Afterwards, an insertion earphone, Etymotic ER-3A, was inserted in the ear to be tested and the stimuli were presented. Visual identification and manual marking of wave I, III and V by two independent researchers. There was excellent the intraclass correlation coefficient among researchers who performed the visual identification of waves I, III and V. The absolute latency of wave I, III and V; and interpeaks I-III, III-V and I-V were analyzed as a function of groups (G1, G2 and G3) and ears. It was observed that the data were not normally distributed by the Shapiro Wilks test. Thus, the Kruskal Wallis test (when there were three quantitative variables) and Mann-Whitney test (in the case of two quantitative variables) were used for intergroup analysis. A significance level of 5% was adopted. Results: When comparing the groups, there was a statistically significant difference in wave V latency, in the I-V interpeak and in the amplitude of wave III of the left ear, with better performance in G1 and G2. In the analysis by ear, we observed significance of wave V latency, interpeak I-V and I-III in G3 and wave I amplitude in G1, noting better results in the right ear. Conclusion: There is no impairment in the neurophysiological responses of the retrocochlear auditory pathway measured in the ABR click stimulus at 80 dB nHL in exposed babies with treated congenital syphilis in the first three months of life.

Key words: Infant. Syphilis. Hearing. Evoked Potentials. Auditory Brainstem Evoked.

505 - Infant Hearing Health Program in a public hospital

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A Program of Infant Hearing Health holds a set of procedures that consists hearing screening, the diagnosis of hearing loss, the vigilance of hearing and language development and the beginning of the intervention when needed. In hearing screening the procedures should be simple and fast done in the neonates in the maternity wards or at no longer than one month of age. Those who do not pass screening should have a comprehensive audiological evaluation at no later than 3 months. Infants with confirmed hearing loss should receive appropriate intervention at no later than 6 months of age. Also, the neonates with risk indicators for progressive and late onset of hearing loss should be monitored for hearing and language development. The goal of the research was to analyze the Program of Infant Hearing Health, done with healthy neonates, considering hearing screening, the diagnoses and the ongoing surveillance of global development of infants with risk indicators for hearing loss. The research was approved by the Ethical Committee from Unicamp. Retrospective research, transversal section, with quantitative and descriptive analyzes of data from the mothers and the neonates of a public hospital, from 2002 up to 2019 in a public hospital. We analyzed data from the mothers in relation to age, schooling and adherence to the Program and from the neonates we studied the risk indicators for hearing loss, the infants responses to the tests and the diagnoses of hearing loss in relation to the degree of loss. For the vigilance of global development we studied the results of the Bayley Scales for Infant Development- Bayley III and the Affordances in the Home Environment for Motor Development-Self Report - Infant Scale. In 17 years of the Program we screened 30,598 neonates. Due to the mother characteristics, we observed that the majority was between 20 and 29 years old, with 9 years of schooling and lived or in the northern area of the city or in the metropolitan area of Campinas. The maximum coverage for hearing screening was 92% obtained in 2018. The majority of the neonates were born term adequate for the gestational age, 18.68% had some risk indicator for hearing loss, the boys had failed more in the screening than the girls and the fail results had occurred more in the left ear. 78.30% infants returned for diagnoses and we found 66 children with hearing loss, with a prevalence of 0,21%. The most common risk indicators associated to hearing loss were: familiar history, congenital infections, craniofacial anomalies and syndromes. There was no association between years of schooling and hearing loss in the child and the mothers age and hearing loss. Also there was no association having risk indicators for hearing loss and degree of loss. Infants with familial history of hearing loss had 4,44 more chances of having hearing loss if compared with infants without familial history; infants with congenital infections had 3,08 more chances and infants with craniofacial anomalies had 10,99 more chances of having hearing loss when compared with infants without anomalies. We concluded that the program should join efforts to screen, diagnose and follow auditory and language development especially in the first years of the child's life.

Key-words: neonates; adherence, hearing loss, neonate screening; diagnosis; early diagnosis.

358 - Early Intervention in Audiology – Policy and the Developmental Context fit, a South African perspective

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Introduction: In the developing world setting, contextual relevance is critical for the success of early hearing detection and intervention (EHDI) programmes, especially in view of the added, extensive challenges these regions encounter. EHDI South African context application has been guided by its statutory Health Professions Council of South Africa (HPCSA), with specific EHDI contexts recommended. Within the South African context, a scarcity of scientific evidence prevails regarding existent intervention strategies relating to promulgated outcomes targeted for the hearing-impaired child below age six.
Aim**:** This study's purpose was thus to explore the South African government's policies regarding early childhood development (ECD) and early intervention (EI) in reference to recommended audiology EI best practice within a developing country context. Specific objectives comprised: a) a review of existing South African regulations, Acts, policies, and delineated outcomes regarding EI; (b) exploring the manner in which these regulations, Acts, policies, and delineated outcomes speak to EI in audiology.
Method**:** A descriptive research design was applied. An online desk review research methodology was conducted of secondary data to retrieve policies, regulations and Acts. Systematic document analysis was employed with the use of deductive thematic analysis in reference to domain summary themes, with the use of respective frequency calculations as appropriate.
Results**:** Considerations of EI for the hearing impaired within the policies, Acts, and regulations were found to be well-intentioned but mostly non-comprehensive. With the exception of the Department of Health, the Departments of Social Development and Basic Education respectively reflected documentation limited in reference to EI specifics for hearing impairment for South African children under age 6.

Conclusion**:** These findings reflect the importance of comprehensive stakeholder consultation within context for formulation, implementation, monitoring of regulations and policies, policy efficacy evaluation and their associated measures of quality assurance regarding early intervention for the hearing-impaired child.
Keywords: *developing context, early intervention, early childhood development, policy*

P.02 – INTERVENTION AND REHABILITATION

450 - Videofeedback-based Remote Follow-up for Families of Babies and Children at Risk for Hearing Disorders: case study
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Family is the potential agent for optimizing the hearing and language environment of babies and children at risk for the development of auditory and oral language skills. Thus, evidence regarding the use of feedback tools in the parental training of caregivers has been presented in the literature. Considering also the inequality of access to hearing health services, resulting from the territorial extension, scarcity of human and technological resources sufficient to meet the needs of the child population in Brazil, the proposition of a remote follow-up clinic, with a focus on babies and children development coming from the child health care network is justified. Thus, the aim of this case study was to evaluate the effectiveness of remote parental training of a family of a child at risk for auditory and language development using the videofeedback tool, as a proposed procedure for the population of infants at risk for the development, in particular, with a history of congenital syphilis, in a remote follow-up clinic. As an instrument, a protocol for analyzing the family-child interaction was used, consisting of a Likert scale of 7 points of frequency of behaviors in the domains of child behavior, caregiver/family behavior, child-directed language and general caregiver´s communicative competence, based on scales for analyzing the interaction in the population of hard of hearing children. The protocol was applied by 3 independent judges at three different times: pre-intervention and 4 and 8 days after the beginning of the proposed intensive remote intervention. The work process for the follow-up of families whose babies and children are at risk for hearing and language development was organized into 10 intervention sessions focused on parental training, understood as welcoming the family, offering guidance from their information needs, reflection on the interaction through videofeedback, and modeling the interaction with the child during the synchronous session. The organization of data, materials and intervention planning took place in software with a cloud-based service. For this case study, each video was then analyzed and mini clips edited for the videofeedback procedure. Custom guidance materials were produced. Clinical meetings were held to structure the intervention process and its follow-up. The Jacobson & Truax (1991) method was used to analyze the intervention's effectiveness. The results showed a reliable clinical change in the child's vocalizations and in the caregiver's communicative competence, with significant improvement in child-directed speech, vocabulary expansion and interaction tuning mother´s behaviors, indicating that the 8-day intensive remote videofeedback-based intervention was effective. It was concluded that the proposal of a remote follow-up clinic based on parental training with the application of feedback technology to caregivers is viable and, based on the case study presented, proved to be effective. Studies with a larger n sample are desirable and could be carried out with the structuring of this remote follow-up clinic to monitor this population.
Keywords: Audiovisual Aids; Formative Feedback; Family; Hearing; Language Development.

210 - Assistive technologies for the rehabilitation of people with sight and hearing impairment and other severe disabilities at the Lega del Filo d'Oro
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For more than 55 years, the Foundation Lega del Filo d'Oro Onlus has been Italy's reference point to assist, educate, rehabilitate, and integrate people with deafblindness and multisensory impairments, empowering them to lead full and productive lives within their communities. It has become one of the most qualified institutions in Europe for the treatment of this disability.
The main causes of deafblindness and multiple disabilities may be acquired or congenital. The former includes birth trauma, hypoxia, tumors, head trauma, oldness, etc.; besides greater life expectancy itself can promote the onset of sensory disorders. At congenital level, causes are due to viral infections (rubella, cytomegalovirus, toxoplasmosis), premature births, various genetic and rare diseases (eg. Usher, Charge, End-Lubinski, Waardenburg, Stickler, Norrie, Alport, etc.) or non-syndromic diseases, etc.
The Foundation has its national headquarters in Osimo (AN), where in December 2017 the new National Center was inaugurated. Inside the Center there is the Diagnostic Unit, which gives a global evaluation and carries out early intervention for children under the age of 4, educational-rehabilitation services, which offer personalized rehabilitation programs, the medical sector, the Research Centre (for the psycho-pedagogical and technological-rehabilitation area), the Documentation Centre, the Territorial Office.
Today, the rehabilitation services of the Lega del Filo d'Oro are carried out in four other Residential Centers (plus the Territorial Offices): at Lesmo (MB), Modena, Molfetta (BA), Termini Imerese (PA) and the five Territorial Offices of Padua, Rome, Naples, Novara and Pisa.
At the Lega del Filo d'Oro for each person and his/her family there is a personalized life project. It is designed and implemented according to each user's age, needs, skills, and environmental resources. Activities cover multiple areas concerning the person's daily life. Equally important is the push for growth – everyone, regardless of age, needs to be continuously challenged in order to acquire and maintain abilities and skills. In order to achieve these goals, many assistive technologies of different types are also employed at the Lega del Filo d'Oro and adapted according to the deficits presented by the user and the severity of the disability.
At the Lega del Filo d'Oro many assistive technologies are used in different activities to promote positive interaction with the environment and supporting alternative communication strategies as well as social and occupational skills of people with multisensory disabilities.
In the rehabilitation microswitch-aid programs are used to stimulate functional activity engagement, occupational engagement, communication, recreation/play, cognitive skills, motor skills, orientation and mobility, inclusion, etc. The use of simple technology devices (e.g. tablet and smartphones) combined with a pictographic or object communication allows to increase the person's autonomy, for example presenting instructions concerning the single steps of the activities programmed.
Tablets and computers, through special software, allow deafblind people to use internet, send e-mails and sms, to call. Our Research Centre develops, assesses and adapts innovative solutions with the growing support of assistive technologies. The publications of articles by international journals on the research projects are a point of reference for national and international professionals that use the assistive technology in education and rehabilitation.
Keywords: deafblindness, rehabilitation, Assistive technologies

363 - Retrieval Practice and Word Learning during a Narrative Intervention for Children with Hearing Loss

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Children with hearing loss (HL) show poorer vocabulary outcomes than children with normal hearing, even when early amplification and intervention are received. Despite their poor vocabulary outcomes, intervention research to support evidence-based practices in children with HL is scarce. The purpose of this study was to assess the effectiveness of three vocabulary teaching strategies (no word retrieval, immediate retrieval, and spaced retrieval) used during a four-week narrative intervention. It was hypothesized that if retrieving words when the answer is not present ("quizzing effect") helps encode words in long-term memory, then spaced-word retrieval will be a more effective strategy than no retrieval and immediate retrieval. A single case alternating treatments research design was used to assess the effect of the three teaching strategies (+ control) on the word learning outcomes of four preschoolers with HL (2 children with cochlear implants and 2 children with hearing aids). Caregivers identified sixteen unknown expressive words using the MacArthur Vocabulary Inventories. These target words were probed and randomly assigned to the different conditions: no retrieval (4 words), immediate retrieval (4 words), space retrieval (4 words), and control (4 words). Children received between 4 and 6 baseline sessions where they completed initial measures (hearing test, vocabulary, language, and non-verbal intelligent standardized tests) and probes to ensure that they did not know the words. During the intervention phase, children received 8 sessions (2 per week) of 40 minutes each. Each session contained 3 narratives, one per condition (no retrieval, immediate retrieval, and spaced retrieval) plus a control narrative.

Narratives were created following the procedures of Story Champs. Children had to listen to and retell a story that provided 11 exposures to the target word. In the no retrieval condition, children were not asked to retrieve the target word. In the immediate retrieval condition, children had to retrieve the target word immediately after exposure. In the spaced-retrieval condition, children had to retrieve the target word and then they received one exposure. In the control condition, children were asked to create a story with the target word, but no exposures or help were provided. Word knowledge was measured at each intervention day, a week, and a month after intervention (maintenance). Inter-observer probe reliability and intervention fidelity were above 90% for all participants. Non-parametric analyses (visual analyses and percentage of non-overlapping data) revealed that the intervention (all conditions) was between minimal and highly effective for all participants, except for participant 3 who did not show improvements in the no retrieval and spaced retrieval conditions during the intervention phase. This means that children learned words only when they were actively taught, and they did not learn during baseline and control phases. When comparing treatments, spaced-word retrieval was the most effective condition for participant 1, however, for all the other participants no differences were observed between immediate and space-retrieval conditions. A month after the intervention, children remembered more words in the immediate and space-retrieval conditions than in the no retrieval condition. Taken together, the results do not support the hypothesis that spaced retrieval is the most effective strategy, rather, children seem to benefit from retrieving words either immediately or spaced. Therefore, clinicians should provide many exposures to new words and encourage children with HL to retrieve words during language therapy to enhance word learning. Future studies should replicate this finding with larger sample sizes.

Keywords: word learning, language therapy, cochlear implants, hearing aids

419 - The rehabilitation of hearing and speech computer program for children with cochlear implants, based on spectral-analytical technologies

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Sensorineural hearing loss, frolicking in childhood, affects psycho-speech development, disrupting the formation of speech and intelligence and general personality development, leading to disability. A big problem is hearing and speech rehabilitation, which has a number of problems in Uzbekistan: delayed treatment for the diagnosis of hearing pathology with a late start of rehabilitation measures revealed persons with different degrees of hearing development, learning abilities, which requires the presentation of material according to the degree of complexity. In this regard, we are developing a program of rehabilitation algorithms using computer technologies based on spectral analysis of hearing and speech.

The system will be implemented on the basis of a standard personal computer or laptop with sound reproduction capabilities (speakers), the WINDOWS 98 and higher operating system and the MS Office suite. All programs of multimedia processing technology are loaded into the computer memory: databases of static data (alphanumeric information, drawings, pictures, written text), application programs for speech recognition or its elements, control programs, which represent the basis of the system software and provide the order of presentation of test sounds , visual reinforcement of them on the monitor screen, general control over the training procedure, including the conditions of stimulation and registration of results.

The created intellectual analysis program will be able to recognize isolated sounds, individual syllables and words, assess the recognition of characteristic sounds of animals or musical recordings, as well as implement other analysis procedures at the request of a rehabilitation specialist (audiologist, deaf teacher).

Computer programs must perform the following actions during operation:

-select an operating mode (training or testing),
- choose the direction of training (a set of exercises),
-determine the order of stimulation (arbitrary triggering of a sound signal or a sequence of stimuli with a specified pause between them),
- to fix the received answers with the help of the lesson protocol in the computer memory.

The final training protocol should contain information about the patient, the date and time of the lesson, the designation of a specific exercise, a list of signals given and their corresponding answers, the primary analysis results - the number and percentage of correct identifications and errors, response gaps, and the average reaction time. All information should be presented in the form of diagrams or graphs for the entire patient group. Classes on the development and consolidation of hearing and speech skills are carried out in the "TESTING" mode. In this case, listening to audio signals is organized without repetitions and feedback. The patient sees only confirmation of his answer. The assessment of the test should be represented by variants of both positive

and negative reactions of the system and the teacher. The resulting tables of grades are saved, and in memory, and can be displayed on the screen immediately after the end of the class.
The created computer programs are presented in the form of separate modules in order to possibly expand the range of trained skills. The task of each module is to develop a certain skill of auditory-speech perception - recognition of speech signals (from isolated phonemes to polysyllabic words), prosodic characteristics of speech (voice, intonation), acoustic orientation, distinguishing sounds of the surrounding world (including musical instruments), highlighting the target signal in the background interference.
The content of the individual modules will include:

- lessons of recognition of speech signals - isolated sounds, syllables and words pronounced by different speakers (the sound characteristics of children from the control group - actually healthy children of the corresponding age will be taken as a basis);
-teaching the skills of highlighting and assessing changes in voice characteristics in speech (question, statement, exclamation);
-recognition of various sounds of the environment: voices of animals, birds, sounds of the house, streets, elements, the sound of musical instruments;
- a set of lessons that help to form the initial skills of spatial orientation, learning to distinguish the spatial position (localization) of a sound (noise) or speech (speaker's words) source, detection of a sound source.

The developed program on the basis of a computer system organizes the rehabilitation of hearing and speech under the guidance of a teacher or self-study of the patient with his parents. An important function of the system is the ability to objectively monitor the results of the training, the dynamics of development and consolidation of speech skills, which will make it possible to purposefully adjust the content of the individual course of study with the patient during his rehabilitation. This is another solution to part of the problem of child disability in Uzbekistan.
Keywords: rehabilitation, hearing loss, computer program, children

373 - Home-auditory-training program with games for patients with tinnitus complaints: a pilot study.
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Tinnitus can have negative consequences on quality of life, such as sleeping difficulties, altered speech perception, anxiety, depressive symptoms, and concentration difficulties. Currently, auditory training has been studied as a possible treatment for tinnitus, supported by the concepts of neuroplasticity, characterized as a set of conditions or tasks aimed at causing positive changes in the central nervous system. Purpose: To assess a home-auditory-training program with games as intervention for patients with tinnitus complaints regarding the tinnitus severity and its psychoacoustic characteristics. Methods: Prospective, non-randomized clinical trial, performed with the approval of the Ethics Committee (nº 2018/16349-6). A pre-selection of tinnitus patients was performed regarding the analysis of their medical records. Analyzed were 445 medical records and 23 were included in the study and allocated into (G1): 15 patients with normal hearing and tinnitus complaints who performed the home-auditory-training program; and (G2): eight patients with hearing loss and tinnitus complaints fitted with a HA who performed the home-auditory-training program. The study was performed in the following stages: Initial assessment, intervention, and final assessment. Results: G1 presented significant differences only for the functional domain of the questionnaire, while G2 presented significant differences between all the domains assessed by the THI before and after intervention. Similar results were found in the VAS analysis because the significant differences were only found in G2. No significant results were found in the psychoacoustic measures and the MML analysis before and after intervention. Thus, no correlation between the THI and psychoacoustic measures was found. Conclusions: The significant differences found in the present study were punctual and the results were positive for the group with combined intervention (G2) regarding the analysis of THI and VAS, before and after the home-auditory-training program, however, the psychoacoustic measures did not show significant differences.
Keywords: adults, hearing loss, tinnitus, questionnaires, neuronal plasticity.

439 - Hearing-related application of the SOC model: Adaptive strategies as indicators of successful ageing with hearing loss
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In the perspective of successful ageing, individuals have a proactive role in lifespan development. One prominent theory of successful ageing is the model of selective optimization with compensation (SOC, Baltes & Baltes, 1990). In this theory, successful ageing goes beyond the achievement of desirable outcomes (i.e. quality of life, health, well-being), but rather reflects human capacities such as loss adaptation and mastery of changes over the life span (i.e. major life events). The SOC model describes such adaptive strategies, namely selection, optimization and compensation. The diagnosis of age-related hearing loss (ARHL) and hearing aid (HA) uptake are two examples of major life events in older adulthood (Filipp & Aymans, 2018). Longitudinal research on SOC (Freund & Baltes, 2002) and adaptation to diseases and chronic illness (Heim, Valach & Schaffner, 1997; Martz & Livneh, 2007) revealed that strategy use also changes over time.
Based on the first application of the SOC model to HA uptake and usage in older adults by Williger and Lang (2014), the current work aims to develop a conceptual framework on the use of hearing-related adaptive strategies. The framework builds on the SOC model and takes a longitudinal perspective to explain successful ageing of adults from the onset of ARHL to the permanent use of HA.
In a first step, a literature review was conducted to identify hearing-related adaptive strategies of adults with ARHL in general. The strategies have been clustered with regard to the principles of selection, optimization and compensation as well as to their occurrence over time by two independent reviewers.
The results of the literature review revealed a vast number of hearing-related adaptive strategies that have been reported in empirical or conceptual work on ARHL. After clustering them regarding the principles of selection, optimization and compensation, we were able to identify further sub-categories that describe concrete adaptive behaviors of adults with ARHL. With respect to selection, we differentiate between the adaptive strategies *Selection of situations*, *Selective use of HA*, and *Withdrawal from situations*. For the principle of optimization, adaptive strategies such as *Control of the environment*, *Preparation and planning*, *Training*, and *Communication strategies* were reported. As sub-categories for the principle of compensation, we identified *Communication strategies engaging others*, *Help of others*, and *Use of external devices*. These sub-categories for adaptive strategies have been mapped over time from the onset of ARHL to the permanent use of HA, if there was respective empirical or theoretical evidence.
In a second step, the conceptual framework will be verified with empirical data from adults with ARHL. Therefore, an interview study with adults with ARHL with and without HA will be conducted. Data will be analyzed using qualitative content analysis (Mayring & Fenzl, 2019) with a mixed inductive-deductive approach. Currently, the empirical study is ongoing, and the results will be presented at the conference.
The conceptual framework on the use of hearing-related adaptive strategies will serve as a starting point for further research and has direct implications for practice.
Keywords: age-related hearing loss, adaptive strategies, successful ageing, lifespan development

48 - Development of Hearing Assessment in Response to Noise Screener (HeARS)
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The purpose of a school hearing-screening program is to identify children who may have an undiagnosed hearing loss and may require further examination and treatment. A review of studies from 1975-2013 suggest that the current method of pure tone and OAE screening are highly variable when identifying preschool and school-age children with hearing loss (Preive et al, 2015). More recent findings suggest that the relationship between speech recognition in noise and auditory comprehension may be capturing difficulties in understanding speech in noise which have been linked to cognitive and linguistic skills (Sullivan et al 2015). However, there is not a current screening method to capture those children who may struggle with speech understanding in noise. While app-based interventions for speech and language exist, to our knowledge, *none* explicitly screen for perception of speech in the presence of noise. To fulfill this need, we have created a screening tool that can identify which children have particular difficulty with speech and language in noisy environments, which we are calling the Hearing Assessment in Response to Noise Screener (or HeARS). We have tested 60 school-age children between 6-12 years of age with no known sensory or neurological impairments. We first presented twenty-five mono-syllabic minimal pair words in quiet, -3 dBSNR (EASY), -6 dBSNR (words from Irwin, 2014). On the offset of the auditory stimuli the screen presents the child with 4 choices that are visual images of the spoken words. For example, the auditory stimuli is "*Show Me Fox".* On the visual display the child saw four pictures: the target (fox) and three foils based on onset (e.g. four), rime (e.g. socks) and a distractor (e.g. barn). Noise for both phases was speech-shaped noise interrupted with silent intervals of 5-95 milliseconds on a 50% duty cycle (Sullivan et al 2013). Scores were recorded as a percent correct. As designed, we report statistically significant differences between the three conditions (quiet, low and high noise), with decreasing accuracy as SNR decreased. Next steps are to establish a typical range signal to noise ratios to develop the app for children at-risk for academic difficulties.

453 - I Hear You - A Game-Based Hearing Screening

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Background**:** Hearing impairment is becoming a public health concern and a worldwide problem. The World Health Organization (WHO) estimates that globally there are about 466 million people with a hearing impairment, of which 34 million are children. Previous studies show that access to health care for hearing in developing countries is inadequate. Implementing alternative, cost-efficient screening methods is therefore an important field of research. For this reason, SINTEF has developed the automated screening application “I Hear You”. The application is developed to be used by non-specialist personnel with limited training.
Purpose**:** The purpose of this cross-sectional study was to examine the reliability and validity of an automated screening method for children. This was done by comparing the screening application "I Hear You" against pure tone audiometry in rural areas in the Kilimanjaro region in Tanzania.
Method**:** 403 children aged 6 to 17 from three different primary schools participated in the study. The measurements conducted in this study were screening audiometry and the game-based screening tool. Children were tested with both methods to assess the sensitivity and specificity of the game-based screening tool, and the instructions were given in Swahili by specialist teachers for each measurement. For both measurements to be approved, the criterion for normal hearing was set to 25 dB HL. The screening audiometry was used as a reference.
The screening audiometry assessment was based on the international standard ISO 8253- 1:2010. The children were presented tones at the frequencies 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz at 40 dB and 20 dB.
The game-based screening tool presents four animals both auditory and visually. Each animal represents a frequency band of about one octave width; 500 Hz (lion), 1000 Hz (elephant), 2000 Hz (bird) and 4000 Hz (grasshopper). The data was analysed with Excel and Receiver Operating Characteristics (ROC).
Results**:** The measurements performed showed sensitivity and specificity for the total sample of 0.65 and 0.62. There were various factors found which influenced the results of the application’s compliance against the reference. Participants in grade 0 to 4 showed poorer sensitivity and specificity compared to grade 5 to 7. The noise measurements registered ambient noise levels between 38.7 dBA and 71.1 dBA. Lower ambient noise is associated with better sensitivity and specificity.
Discussion**:** Various factors were identified that may have affected the application's compliance with standard pure tone audiometry. Factors that are considered to have a major impact are age, noise, and what criterion for hearing impairment is used in the application. The screening application generally showed poorer sensitivity and specificity, compared to previous studies. Out of the total sample of 403 children, 116 were misdiagnosed with hearing impairment. Younger children were often observed as more unsure of the test. In this study children were not re-tested, as done in previous studies (Yeung et al. 2013 & Kam et al. 2014). If the procedure of re-testing of participants had been introduced, it could affect the sensitivity and specificity in this study. In this study, the classrooms had poor acoustic isolation, with concrete walls and bare floors. These acoustic challenges are shown to have a negative impact on sensitivity and specificity (Yeung et al. 2015, p. 1250). This study implies that lower ambient noise gives better consistency between audiometry and the application “I Hear You”.
Changing the criteria for normal hearing will impact the sensitivity and specificity. Based on the influencing factors and criteria used in the application, the results show poor agreement. It could be interesting with further research on which different criterias are advantageous for automated screening, both for financial and clinical utility.
Conclusion**:** As of today, the screening application shows poor compliance with pure tone audiometry using the current criteria in the application, with all influencing factors included. The results suggest that with further improvements to the application as well as possible re-testing, “I Hear You” might become a feasible option in the future to conduct cost-effective routine hearing screenings.
Acknowledgements**:** The authors wish to thank all the children who participated in this study, Patandi special needs teacher College, and Open University of Tanzania (OUT) who assisted in data collection. We would also like to thank SINTEF for contributing and making this research possible.

486 - Suppression Otoacoustic Emission (Suppression OAE) using Various Contralateral Suppressors among Autism Spectrum Disorder Children

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Background**:** Auditory sensory gating deficits is one of the abnormalities in autism spectrum disorder (ASD) patient that may lead to sensory processing difficulties. It is particularly difficult for ASD children to discriminate multiple auditory stimuli, which hinders them to focus on one auditory stimulus and separating unnecessary sounds. Suppression OAE is a tool used to identify sensory gating deficit in the general population and specifically for ASD children. This paper aims to investigate the suppression effect among ASD children using various types of sounds suppressors to measure their sensory gating capacity.
Methods**:** Twenty children consist of ten ASD and ten normally developing children aged 6 to 12 years old were recruited for this study. Both TEOAE and DPOAE was performed from one accessible ear whereas suppressor sounds were presented on another ear. The contralateral suppressors include white noise, environmental sounds, natural sounds, Quranic recitation, airplane, air condition compressor and piano sounds. The amount of OAE suppression was determined from the difference between OAE amplitude baseline without masker and with masker (in dB sound pressure level) for all sound types. Sound with the highest suppression effect was determined using effect size calculation and RM ANOVA at 95% confidence level. A high suppression effect may suggest high sensory gating performance while low suppression may indicate low sensory gating performance.
Results**:** Based on the analysis, sound with the highest suppression effect were waterfall and sound with the lowest suppression is river.
Conclusion**:** This study provides a better understanding of the alternative sound stimuli to assess sensory gating deficit among ASD children besides the standard white noise tone. Sound with a high suppression effect has the potential to be used for sound therapy intervention among ASD children as part of rehabilitation and therapy.
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Keywords: Autism Spectrum Disorder (ASD), Sensory Gating, Suppression OAE

P.03 – HEARING LOSS MECHANISMS AND MEDICAL ISSUES

466 - The hearing Loss in Meniere's Disease

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The pathogenesis of hearing loss in Menière's disease (MD) remains obscure, with endolymphatic hydrops (EH) being considered a fundamental abnormality. However, the variability of histological, electrocochleographic and otoacoustic emission findings and inconsistent efficacy of diuretic and surgical treatments, pertinent to the assumed EH, make the presence and importance of EH questionable in the large proportion of patients with MD. This raises the suspicion that another mechanism(s) is involved.
The current understanding is that the volume and pressure of EH increase the impedance of the basilar membrane, leading to a reduction of the sensitivity to sounds and, therefore, hearing loss. Traditionally, auditory sensitivity has been evaluated by the standard pure audiometry, while cochlear function is assessed in more detail by electrocochleography and, more recently, by otoacoustic emissions (OAEs).
This study describes a site-of-lesion assessment in 120 patients with MD. They underwent standard pure-tone audiometry (PTA), tympanometry, stapedial reflexes (SRs) to evaluate the structural integrity of the cochlear inner hair cells (IHCs), otoacoustic emissions to evaluate the outer hair cells (OHCs); the auditory brainstem evoked responses and CT and/or MRI for exclusion of retro-cochlear pathology.

The PTA showed elevated hearing thresholds at two or more frequencies (0.5-2 kHz range): 30-40 dB in 23%, 40-70 dB in 68% and >70dB in 9% of the patients. This means that the hearing loss in 91% of the patients does not exceed 70 dB flat configuration. SRs were recordable in 90% of patients. OAEs were recorded in 61% of the patients, 73% of whom had PTA thresholds ≥ 40dBHL.
The findings of mild/moderate hearing loss and present SRs (which indicate preserved IHCs) in the overwhelming majority of the patients are suggestive of a selective lesion of the cochlear outer hair cells (OHCs). This is supported by previous findings that selective OHC damage reduces hearing sensitivity by 40-50 dB and that MD becomes stable when hearing thresholds reach ~ 60-70dB level. The presence of OAEs in a significant number of patients with reduced hearing sensitivity implies some form of functional cochlear disorder.
This discrepancy between audiometric thresholds and OAEs would not fit into the classic picture of MD with underlying EH and, therefore, it is suspected that EH may not necessarily be underlying pathology in these cases. Other, alternative mechanisms will be discussed.
In summary, this study provides evidence suggesting that a selective OHC lesion, functional or structural, is the typical pathophysiological feature of MD. The loss of cochlear non-linearity, for which OHCs are assumed to be responsible, may explain a number of auditory symptoms in MD.
EH could be considered a secondary phenomenon resulting from disordered inner ear homeostasis, but not essential factor in pathogenesis of MD.
Key words: Meniere's, hearing, otoacoustic emissions

81 - ABO blood group and auditory function
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Objectives: The ABO blood group system classifies human blood based on the genetic characteristics of red blood cells, which are determined by the presence of antigens A and B on the surface of red blood cells. Therefore, persons may have type A, B, O, or AB blood. Many research studies have found an association between the prevalence of specific health conditions and individual ABO blood group status. Examples of ABO blood group and human health association include findings that group A individuals are more prone to gastric cancer while group O individuals have increased risk of peptic ulcers. Comparatively little research has examined the possible association of ABO blood group status and auditory function. Several studies have found that blood group O workers tend to have a higher prevalence of noise-induced hearing loss compared to those with blood group A, B, or AB. More recently, a number of small-scale studies have noted blood group O individuals show comparatively lower otoacoustic emission (OAE) amplitudes and lower speech perception in noise scores. The present study examines the effect of ABO blood group status on auditory function in a much larger scale cohort than any previously undertaken research.
Methods: The present study assessed the hearing status of a large sample of participants [n=463, and approximately equal numbers for each ABO blood group] and involved a detailed assessment of hearing functioning using a range of hearing tests—pure tone audiometry, ultra-high frequency audiometry and a tone in noise detection test. Examiners are blind to participant blood group status. Participants aged 20 to 59 years were recruited. These ethnic Han Chinese participants had an accurate knowledge of their ABO blood group from blood donation, blood test and/or information from authoritative sources. Included participants passed a pure tone audiometry test with thresholds of 25 dB HL or less at 500, 1000, 2000, 4000 and 8000 Hz in both ears (clinically normal hearing). Also, ratings 0 or 1 in both ears on the Sullivan cerumen scale are required for all included participants.
Results: This experiment hypothesized that participants with blood group O would show poorer auditory performance than those with non-O blood groups. Appropriate ANOVA and non-parametric tests were used in data analyses. In this large-scale study, the results did not support the hypothesis. There were no statistically significant differences between participants with different blood groups in ultra-high frequency hearing thresholds or in tone in noise detection test. However, this study found age-related decline for ultra-high frequency hearing thresholds and tone in noise detection test results. These results were consistent with prior studies.
Conclusion: Our large sample size study did not support the original hypothesis of reduced auditory function in participants with blood group O. However, to further explore the relationship between ABO blood group and human auditory function, research should focus on populations with hearing loss or specifically NIHL and consider the potential effects of blood group on the risk of developing hearing loss.

418 - Neuroaudiology and speech recognition to differentiate between cochlear and auditory neuropathy in advanced age

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Objective: To identify cochlear and auditory neural dysfunction in 85-year-olds and to study in what extent poor speech recognition in advanced age can be explained by auditory neural dysfunction. Design**:** The study design was cross-sectional. A comprehensive test protocol was used, including pure-tone- and speech audiometry, auditory brainstem responses (ABRs) and distortion product otoacoustic emission (DPOAE). Study sample: This study comprised unscreened 85-year-olds (n=125), born in 1930, as part of the Gothenburg Birth Cohort Studies, the H70-studies in Sweden. Results**:** The vast majority had sensorineural hearing loss associated with cochlear damage. Only 1.6% had neural dysfunction according to abnormal ABRs. Approximately 20% had abnormal speech recognition (in relation to SII predicted word scores), whereas only two subjects had abnormal ABRs. Conclusion**:** The cochlear sub-type of auditory dysfunction was most common in advanced age. Abnormal speech recognition scores were only rarely associated with abnormal ABR wave V latencies, i.e., auditory neural dysfunction in 85-year-olds. Further studies, including variables for central auditory processing and cognition need to be included for a better understanding of auditory neural dysfunction and poor speech recognition in Age-Related Hearing Loss.
Keywords: ARHL, Speech in noise, ABR, DPOAE

477 - Characterization of Otoacustic Emissions in adults with HIV and/or acquired syphilis

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Introduction: The auditory system is a complex structure composed of sensory organs that constitute its peripheral and central portion. There are external factors that can act as harmful agents and cause damage to the inner ear, such as sexually transmitted infections (STIs), which have increased a lot in Brazil and in the world, and, therefore, considered a global public health problem. HIV and syphilis are known causes of sensorineural hearing loss and the occurrence of coinfection is frequent. It is known that the cochlea, semicircular canals and vestibulocochlear nerve may be compromised. Therefore, in addition to hearing loss, tinnitus and dizziness are the main complaints of non-auditory symptoms in this population. Such damage can occur due to the action of Treponema itself and/or the virus and, in the case of HIV, also due to ototoxic medications used in antiretroviral treatment (ART) and due to the emergence of opportunistic infections. Despite this, there are few studies that assess this damage.
Purpose: to characterize the findings of transient evoked otoacoustic emissions (TEOAE) and distortion product otoacoustic emissions (DPOAE) in individuals with HIV and/or syphilis.
Methods: prospective observational sectional study carried out in Public Services in Natal, approved by the Institution's Research Ethics Committee under n. 4.627.820. Fifty subjects of both genders, aged 18 to 59 years and 11 months divided into three groups: G1: 25 adults with HIV; G2: seven adults with HIV and syphilis (coinfection) and G3: 17 adults without a diagnosis of acquired syphilis and/or HIV or other pathologies that indicate a risk for hearing loss. The research protocol consisted of anamnesis associated with the analysis of medical records and the following procedures performed with the TITAN equipment of i*nteracoustics*: tympanometry with a 226 Hz probe, TEOAE and DPOAE. The emissions were considered present when there was a signal-to-noise ratio greater than or equal to 6dB in at least three frequencies, in addition to >50% response reproducibility and >70% probe stability for TEOAE.
Results: the sample was composed predominantly being male (74%). It was found that G1 and G3 had a higher percentage of passes in the TEOAE and DPOAE in both ears. G2, with co-infection of syphilis and HIV, had 42.85% of TOAE failure in the RE and 14.28% in the LE. Regarding amplitude, the results were similar in all groups. Conclusion: As for the audiological findings, there was a possibility of alterations in the TEOAE and DPOAE with evidence of cochlear alteration in subjects with co-infection between syphilis and HIV.
Keywords: Hearing; Hearing Loss; Acquired syphilis; HIV; Hearing tests.

260 - Audiological evaluation in ZIKA virus

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There are many studies that prove the relation between ZIKA virus and hearing loss. It's for this reason that in our Audiology Department we perform the following audiological study: to confirm or discard hearing loss in children with this viral infection transmitted by their mother during their pregnangy.
This retrospective study, which was started in 2017, evaluates the auditory function with Auditory Brainsteam Response (ABR), using the click stimulus, in a series of 40 children. The patients were collected from the National Referal Unit for Tropical Disease, from Sant Joan de Déu Children's Hospital.
The monitoring protocol was to evaluate their hearing threshold twice: at 6 months and 12 months from birth.
The results of this study show that all the children evaluated have a normal hearing threshold in all the test done during the follow-up.
Conclusion: The relation between ZIKA virus and hearing loss could not have been proved in this study, because all the children evaluated have a normal hearing threshold in the ABR test. Even though, our Department continues with the protocol stablished to confirm the results explained before.

395 - Building blocks for emotion regulation in children with and without hearing loss

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Background**:** Emotion regulation (ER) involves the ability to adjust the level of emotional arousal (coping) and express emotions adaptively to achieve (social) goals. Keeping one's emotions in control when disagreeing with others can prevent the escalation of conflicts. Having reasonable control of one's own emotions also leaves space for acting prosocially. Thus, ER is crucial for children's social adjustment and peer relationships. Typically hearing (TH) children develop ER skills through social learning without much efforts, such as discussing emotional situations with caregivers, observing how caregivers and peers deal with emotion-provoking situations and interacting within these daily social contacts. However, most hearing loss (HL) children are raised in a predominantly hearing environment. This might raise difficulties in communication, which influences HL children's language development and presents challenges for developing their emotional skills. To date, little is known about ER in HL children in their preschool years, which is the focus of this study.
Method**:** 222 preschoolers (104 HL and 118 TH) were recruited in China. Parent questionnaires measured emotion expressions (i.e., positive and negative emotions). Coping strategies, including approach and avoidance styles, were examined by asking children to name their coping strategies in various emotion-provoking situations and by observing children's reactions in a frustrating situation in real-time.
Results**:** HL children named fewer approach and avoidance strategies than TH children. However, in the observation task, HL children used the avoidance strategy to the same extent as TH peers. Parents reported similar levels of negative emotion expressions for HL and TH children, whereas HL children were reported to express fewer positive emotions than TH children.
Conclusions**:** Our findings showed that HL children performed similarly to their TH peers in some but not all ER skills. Although they showed a similar level of avoidant coping in a real-life task, they thought of fewer coping strategies than TH children in hypothetical situations. Regarding emotion expression, HL and TH children showed similar levels of negative emotions, but HL children communicated fewer positive emotions, based on their caregivers' reports.
On the positive side, HL children seem to communicate their negative emotions well, thus addressing their needs and wishes in contact with their caregivers. Yet, they also seem able to distract themselves in frustrating situations, which is also useful for dealing with their negative emotions, as caregivers are not always around to support them, and this shows a certain level of understanding of social rules. In other words, one is not supposed to throw an angry tantrum in front of a stranger when things do not go one's way when at 3 or 4 years old. Both HL and TH children seem to understand those social rules to the same extent.
However, the communication of positive emotions has a social function that HL children do not seem to fully understand. Expressing positive emotions is essential for bonding and for the continuation of certain behaviours within a relationship that is valued. Also, the coping vignettes that children were presented with

required more social understanding than the avoidance coping task, and lower scores were found in HL children than their TH peers. Alternatively, it might be argued that HL children show fewer positive emotions because they do fewer fun activities with their caregivers, but more often have hospital visits, and so on. Additionally, the coping vignettes were more cognitively and verbally demanding than the avoidance coping task, which could have caused the lower scores in our HL participants. Future studies could further examine the plausibility of these different assumptions.
Keywords: Hearing loss, preschool children, emotion regulation, coping strategy, emotion expression

510 - The Clinical Follow Up of Psychosocial Difficulties in Children With Hearing Loss: One Year of Patient Reports
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Objectives Children with hearing loss have a higher than normal risk for experiencing difficulties in social-, emotional-, and behavioral domains. Earlier studies found mixed results on the specific indices of psychosocial difficulties, in relation to explanatory variables. This study aims to identify the prevalence of specific psychosocial difficulties, along with child- and environment-related risk factors, using the Strengths and Difficulties Questionnaire (SDQ).
Methods A cross-sectional design is used for the present study. From July 2020 – March 2022, parents and children are asked to fill out the SDQ, during the child's clinical follow-up in the department of audiology. Prevalence of gross-total and individual psychosocial indices are calculated. Child-related risk factors like hearing device, hearing acuity, auditory functioning, and environment related risk factors, such as type of schooling are analyzed for association with psychosocial difficulties, using univariate correlation-, and multivariate regression analyses.
Preliminary Results A total of 312 children were included for analysis. Results of the analyses will be presented on the *HEAL CONGRESS 2022*
The preliminary results of the first 217 participants show that 17% of the children had clinically deviant parent-reported psychosocial outcomes. Specifically, hearing impaired children had poorer outcomes on emotion regulation and peer relationships. Group status (cochlear implant vs. hearing aid) had no effect.
Discussion Additional variables will be used to compose a regression analysis to identify hearing impaired children's risk for psychosocial difficulties.
Discussion on the results will be presented on the *HEAL CONGRESS 2022.*

P.04 – EPIDEMIOLOGY OF HEARING LOSS

351 - Pilot hearing screening among school age children in Nigeria, Lagos
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Background Nigeria is a country where half of the population lives on the edge of poverty, without access to drinking water. In addition, the negligible development of otolaryngology and the lack of financial resources for health care, results in the lack of screening hearing tests of newborns, which are becoming to be a standard procedure in other countries. Hearing disorders disturb the child perception of sound, as well as the development of speech which in consequence negatively affects the child relations in society. The early detection of hearing impairments in children enables the effective implementation of medical and rehabilitation procedures or preventive treatment.
The aim of hearing screening in Nigeria was assessing the level of hearing in the group of school-aged children, as well as increase knowledge in the field of otolaryngology. The IFPS (the Institute Psychology and Pathology of Hearing) team provided numerous consultations, held interviews with teachers and provided guidance and information on diagnosis, treatment and auditory rehabilitation.
Materials Hearing screening was performed in group of 289 children from 5 to 12 years old. The most numerous group were children in 6-7 years old - 38,2% of tested pupils. Prior to testing, the children's parents were informed of the testing procedures and provided their written consent.
Methods All children were examined following tests: videootoscopic, pure tone audiometry which was performed on Sensory Examination Platform and also OAEs. Positive results of the screening test was defined as any hearing impairment greater than 20 dB HL in any ear, at any frequency from 500 to 8000 Hz. The results of the audiometric tests were supplemented by the results of the questionnaire completed by the parents. This questionnaire including question concerning data on the potential causes of the child's hearing problems, medical history, possible presence of tinnitus, and any presence of learning difficulties.
Results Analyzes of videootoscopy results showed that over 51% of the examined children had an incorrect result (including excessive earwax, mycosis, middle ear infections), of which almost half of them had this problem on both sides.
OAEs present in both ears was recorded in 30.5% of examined children, only in one ear in 28%, while the absence of otoacoustic emissions in both ears was found in 41.5% of tested children.
A hearing threshold value of 30 dB or more for at least one frequency in at least one ear was assumed to be a positive result of pure tone audiometry. In the group of children with positive results, moderate hearing loss was most commonly observed.
Conclusion Hearing screening conducted in Nigeria has once again confirmed the need to disseminate knowledge in otolaryngology, especially regarding ear hygiene. The results obtained suggest a significant prevalence of hearing problems. Based on the results, it would be important to introduce hearing screening as a routine, standard procedure. These tests should be carried out as soon as possible. Due to limited funds, it is important to introduce solutions generating minimum costs.

353 - Hearing Screening among First-Grade Children in Rural Areas and Small Towns in Małopolskie Voivodeship, Poland

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Background Undiagnosed hearing deficits hamper a child's ability to learn. Hearing screening in school aged children helps detect educationally significant hearing loss and prevents negative impacts on academic achievement. The main purpose of this study was to improve early detection and assess the incidence of hearing disorders in first-graders from rural areas and small towns in the Małopolskie Voivodeship of Poland.
Materials and Methods There were 5029 children aged 6–7 years. Hearing thresholds were measured over the frequency range 0.5–8 kHz. A result was considered positive (abnormal) if the hearing threshold was worse than 20 dB HL at one or more frequencies. The prevalence of hearing loss was estimated in terms of four-frequency hearing loss, high-frequency hearing loss, and low-frequency hearing loss. Parents filled in a brief audiological questionnaire. The analysis was performed using IBM SPSS Statistics, version 24.
Results Of all the children, 20.5% returned a positive result and were referred for further audiological diagnoses. The estimated prevalence of hearing loss was 11.6%, made up of 6.5% with FFHL, 7.6% with HFHL, and 8.2% with LFHL.
Conclusions This study showed that large numbers of children in the district had hearing problems. Adoption of hearing screening in primary schools is recommended as a routine procedure within preventive pediatric health care.

354 - Hearing loss among 1st and 6th grade children of primary school in Warsaw, Poland – cohort study

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Background Hearing disorders disturb the child's perception of sound, as well as the development of speech which in consequence negatively affects the child relations in society. The early detection of hearing impairments in children enables the effective implementation of medical and rehabilitation procedures or preventive treatment. Therefore hearing screening have an extremely important preventive task, being the primary means of secondary prevention. They allow for an early detection of hearing disorders, thus enabling treatment and eliminating or minimizing the negative consequences associated with this type of dysfunction. The recognition of the importance of screening programs targeted at these age groups is confirmed by, among others signing of European consensus on hearing, sight and speech screening by European audiological, ophthalmic and speech therapy societies. In recent years, the Institute of Physiology and Pathology of Hearing has implemented many hearing screening programs in the capital of Poland – Warsaw in cooperation with President of Warsaw.
Material and Methods Analysis was performed on 102 753 results of audiometric screening examinations performed in 7 and 12-year-old children, attending the 1st or 6th grade of a primary school in Warsaw, during 5 school years (from 2014/2015 to 2018/2019). 55,6% of the group was 7 years old. All children underwent tone audiometry hearing examination in frequencies 0.5, 1, 2, 4 and 8 kHz. Tests were performed using the screening device – Sense Examination Platform. Hearing loss was defined as air threshold values of 25dB HL or greater for any frequency at least one ear.
Results Analysis of the obtained results of hearing screening showed that the positive result of the audiogram was found in 15 105 children (around 14,7% of the surveyed population). Among children aged 7, the percentage of positive results was 17,7%, while in children aged 12, it was 11%. In addition, there was a large number of unilateral hearing losses.
Conclusion Any loss of hearing sensitivity constitutes a major barrier to effective learning as all formal learning activities in school environments are mediated through the sense of hearing. Hearing screening programs should be initiated for school-aged children to support equal educational opportunities for children who suffer from communication disorders. The school-age hearing screening has been shown as an effective and accessible mean of identifying impairments that were not diagnosed until school-age, as well as those developed during this period, fulfilling its objective to minimize the difficulties and losses due to hearing deficits. The presented results once again confirm the need to implement routine hearing screening among school children. In accordance with the adopted rules of programs implemented by the Institute of Physiology and Pathology of Hearing, children are immediately referred for detailed examinations to local specialists in order to undertake proper treatment.

433 - Hearing loss in old age – prevalence and type of hearing loss in two unselected groups of nonagenarians

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Objective**:** As more years are added to our expected lifespan, the urgency to focus on better health and functionality for all ages increases. Nevertheless, health research involving older persons is often less representative than in younger age groups, partly due to selection bias and confounding factors. Studies on hearing loss in persons over 90 years of age are mostly based on subjective hearing assessments, on medical journals or non-standardised hearing measurements. The high comorbidity with other age-related impairments such as dementia further emphasizes the call for relevant and representative data on hearing ability. The aim of this study was to obtain representative data on type, degree and prevalence of hearing loss in persons aged 89 and older, in order to complement a gap in hearing research.
Design**:** A cross-sectional study on hearing ability was performed. Classification of hearing loss was based on standardized audiological tests performed in the participants' homes – including nursing homes and institutional settings – to minimize dropout.

Study Sample: Two unscreened groups of persons born 1930 and 1923/24, aged 89-90 and 95-96 (n=92) were included. The participants were recruited from the Gothenburg H-70 Birth cohort studies and no exclusions were made except consent given by the participant or a close relative.
Results**:** Hearing loss is very common in persons aged 90 and above and all the participants in this study showed some degree of hearing loss affecting both ears. Preliminary results also show that most had a sensorineural hearing loss classified as moderate to moderately severe or worse on the better ear according to the WHO grades of hearing impairment, indicating the need for hearing rehabilitation.
Conclusion**:** The prevalence and degree of hearing loss in nonagenarians indicate the importance of continued testing and rehabilitation of hearing loss throughout a person's life. However, audiological testing and rehabilitation must be adapted, considering the potentially high comorbidity with cognitive and physical impairment in this age group.
Keywords: Age-related hearing loss, "oldest old", nonagenarians, standardized audiometry, epidemiology of hearing loss.

483 - Age-related hearing loss in the Korea National Health and Nutrition Examination Survey
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Objectives Age-related hearing loss (ARHL), also known as presbycusis, is a chronic disorder characterized by impairment of the transduction of acoustic signals. This study analysed the prevalence and demographic characteristics of ARHL in the Korean population.
Methods We used the data from the Korea National Health and Nutrition Examination Survey (KNHANES) from 2009 to 2012 and analysed the association between age and hearing impairment. A total of 16,799 adults were selected for the current study. Physical examinations, blood tests, otoscopic examinations, and hearing tests were performed. The demographic variables included age, gender, obesity, economic status, education level, noise exposure history, and underlying diseases.
Results Among 16,799 participants, the prevalence of unilateral hearing loss was 8% (1,349 people), and bilateral hearing loss was 5.9% (989 people). Men were 53.4% more likely to have hearing loss than women. Age and underlying diseases, like hypertension, diabetes, and abdominal obesity, were significantly associated with hearing loss ($P < 0.0001$). Further, mental health factors, such as cognitive function, depression, and suicidal ideation, were related to hearing loss. The prevalence of hearing loss increased with advancing years, especially in the high frequency of 6 kHz, with a sharply increase in patients aged 65 and over.
Conclusion The analysis of auditory performance in the Korean population confirmed the association of high-frequency hearing loss with advancing age. A threshold of 6 kHz should be included to correctly diagnose hearing impairment in elderly patients. Patients with ARHL should be provided with suitable aural rehabilitation that includes active high-frequency control.

P.05 – AUDITORY PERCEPTION

340 - Better speech-in-noise comprehension is associated with enhanced neural speech tracking in older adults with hearing impairment
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The alignment between low-frequency activity in the brain and slow acoustic modulations in the speech signal depicts a core principle in present theories of speech perception—a process referred to as "neural speech tracking". While most older adults, particularly those with the highly prevalent age-related hearing loss, have difficulties with speech perception and comprehension, the impact of hearing loss on neural speech tracking is still unclear.
In this study we investigated the effects of pure-tone hearing loss and different types of background noise on the neural tracking response in a large sample of older adults ($N = 101$). Furthermore, we examined whether the neural tracking response was predictive for speech comprehension. For this purpose, we obtained scalp EEG of our older participants who had varying degrees of pure-tone hearing loss (7.5–59.6 dB HL for 0.5–8 kHz pure tones) while they listened to sentences in quiet, pink and multi-talker babble noise. Speech tracking was quantified by computing the cross-correlation between the EEG signal and the amplitude envelope of the sentences heard. For statistical analysis, a control condition was created by correlating the EEG signal with

randomly selected, not presented sentences. Each condition was tested against said control condition in order to obtain significant electrodes and time lags. Subsequent hypothesis testing was done using linear mixed-effects modelling. A higher degree of pure-tone hearing loss was associated with a greater speech tracking (i.e., greater cross-correlation). Multi-talker babble noise, but not pink noise, resulted in neural tracking decrements. Lastly, neural speech tracking showed a positive association with speech comprehension. Importantly, this association was modulated by the degree of pure-tone hearing loss where participants with worse hearing benefitted more from a greater neural speech tracking. Our results highlight the potential of neural speech tracking as an objective measure of speech comprehension and as a possible target mechanism for clinical interventions such as neurofeedback. Furthermore, the interaction between speech tracking and pure-tone hearing loss suggests a compensatory mechanism by which the hearing-impaired rely more on the slow amplitude modulations in the speech signal.

134 - Turkish Native Children & Adults' Voice Perception and Gender Categorization Abilities: A Comparison with Previous Dutch Data

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Background and Objectives: Human voice — the carrier of speech — has two basic vocal characteristics: fundamental frequency (F0, related to pitch) and vocal-tract length (VTL, related to speaker size). F0 and VTL cues are best known for their reliability in perception of a speaker's gender and age (Belin et al., 2004, Tr. Cogn. Sc. 8:129). Previous research has shown that normal-hearing (NH) adults can recognize even a small change in VTL or F0, and, perhaps as a result of this sensitivity, can make correct judgments about the speaker's gender. In contrast, age effects on voice discrimination and gender categorization abilities during cognitive development in children are relatively unknown. In this study we investigate voice perception abilities in NH adults and children by measuring F0 and VTL just-noticeable differences (JNDs) and gender categorization. We aim to (1) characterize voice perception development as a function of age, (2) determine the age at which children show adult-like voice perception, and (3) assess how data from Turkish speakers compare to previously collected data with Dutch speakers with the same objectives.
Design**:** For two experiments, we included 72 NH adults (18-35 years age), and 64 NH children (5-18 years age) split over 6 age groups. All participants were native Turkish speakers. In Experiment #1: the F0 and VTL JNDs were evaluated using a 2-down-1-up adaptive odd-one-out task. The participants were presented three consonant-vowel (CV) triplets, with one triplet differing from the others in VTL or F0 value. The participants were asked to select the odd stimulus by pressing on the corresponding button on the touchscreen of a laptop. The JNDs correspond to the F0/VTL difference yielding 70.7% correct discrimination. In Experiment #2: The perceptual weights given to F0 and VTL were measured in a gender categorization task by manipulating speaker voices in increasing or decreasing F0 and VTL values in semitones (st). The participants initially heard a consonant-vowel-consonant (CVC) word in their native language, and then a gender figure — man or woman — appeared on the screen. The task of the participant was to indicate whether the gender of the auditory stimulus matched the gender of the visual stimulus by pressing a button on the touchscreen of a laptop. The design of the study was based on a similar procedure involving native Dutch speakers (Nagels et al., 2019, CIAP; with a smaller age range of 5-12 years), and the PICKA testing interface, developed at UMCG, was used to administer the tests.
Results**:** Experiment #1 show that Turkish adults are sensitive to F0 and VTL JNDs, with thresholds around 2.1 st and 1.7 st, on average, respectively. The preliminary data with Turkish NH children imply a development in F0 and VTL perception as a function of age, but more data are needed in individual age groups to evaluate at what age sensitivity becomes adult-like. In Experiment #2, again a developmental effect in gender categorization as a function of age is seen in children, and it appears that the weight given to F0 for gender categorization starts to become adult-like at earlier ages while VTL becomes adult-like at later ages. These preliminary results are similar to the results previously obtained in the Netherlands.
Conclusions**:** In comparison to the Dutch data, the Turkish study has a wider age group, beyond 12 years old. Our findings, hence, extend and support the previous Dutch data in means of voice perception sensitivity, gender categorization and age effects in children, and indicate cross-language generalizability of the

developmental effects on voice perception. Increasing the number of participants per age group will provide a better gradual analysis as a function of age.
Key words: voice perception, gender categorization, age effect

135 - Vocal emotion recognition of children with normal hearing and with hearing aids
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Background and objectives: Past research suggests that emotion recognition plays a crucial role in children's development. Studies of emotion recognition have been conducted mostly with visual materials. High-quality auditory stimuli are necessary to study vocal emotion recognition in populations with normal and impaired hearing. In this study, we investigate vocal emotion recognition performance by native-Turkish pediatric and adult listeners using pseudo-speech sentences conveying one of the three possible emotions: happy, sad, or angry. The primary objective is to obtain normative developmental data for normal-hearing (NH) children, which can be used to norm data obtained from hearing-impaired (HI) children.
Design**:** 64 native Turkish NH children (planned to be between the ages of 5 and 17 years) divided into 6 age groups, and 72 native Turkish NH adults between the ages of 18 and 35 years were investigated. Pseudo-speech sentences, taken from the Geneva Multimodel Emotion Portrayal (GEMEP) Corpus (Banziger & Sherer, 2010), were recorded from multiple speakers in accordance with the happy, sad, angry emotions (for more details, see Nagels et al., under review, PeerJ). A computer-based interface that includes visual feedback was developed by University Medical Center Groningen (UMCG) and constructed using MATLAB. Participants were instructed to listen to a pseudo-speech sentence via headphones (or via speakers for HI participants) and asked to select one out of three faces displaying the same three emotions — happy, sad, and angry — when they appeared on the screen. To facilitate understanding of the task, training trials were first completed. The total duration of the experiment was approximately 6 to 8 minutes.
Result**:** Visual inspection of the preliminary data suggests that mean emotion recognition accuracy for NH adults is 83%. NH children's scores per age group improve increasingly with age. The youngest group tested thus far, 7-9 years, achieved 50% accuracy, and performance improves to 73% for an older group of 13-15 years. For both children and adults, 'sad' is the most accurately recognized emotion (NH adults = 100%; NH children 13-15 years = 90%). In comparison, 'anger' and 'happy' yield about 83% and 73%, respectively for adults, and both 70% for the 13-15 age group.
Conclusions**:** These normative developmental trajectories will be used for comparison with data from HI children that is currently being collected (with children with hearing aids) and will also be presented. In addition, for cross-language generalizability, these data can be compared to identical experiments performed in the United Kingdom and the Netherlands. Preliminary comparisons indicate that the current test of Emotion Recognition Test for Hearing Impaired Listeners
(EmoHI Test) is suitable for use with populations of children and adults with normal and impaired hearing across different languages.
Keywords: Hearing aids, Emotion recognition, Emotion perception

404 - TESTE LISTENING IN SPATIALIZED NOISE SENTENCES- LISN-S IN BRAZILIAN PORTUGUESE: SENTENCE EQUALIZATION STEP
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Introduction**:** The Listening in Spatialized Noise Sentences (LISN-S) is a test to evaluate auditory spatial processing. Currently it is only available in the English language. Therefore, a study is being carried out to develop the LISN-S test in Brazilian Portuguese, including presentation software, audio database in Portuguese and normality criteria for a age group from 6 to 11 years old. The steps to develop a software to assess spatial processing and speech material for the Portuguese database, which was inserted into the software, were concluded. Moreover, sentence intelligibility equalization has also been completed and the entire process will be described below.
Design**:** This is a cross-sectional study approved by the Institution's Ethical Commitee, under nº. 3,462,572. The sample consisted of 35 adults aged between 19 and 40 years, median of 22 years (30 females and 5 males) and 24 children aged between 8 and 10 years, median of 9 years (8 females and 16 males). Inclusion criteria included normal hearing and good performance at school. Initially, the audiological assessment was applied which consisted of pure tone audiometry, speech audiometry and immittance testing followed by school performance test, which included writing and reading assessment. The Sentence Intelligibility Test was applied through a computer coupled to a Sennheiser HD 280 PRO headset via an RME Madiface audio interface. Each volunteer was instructed to repeat the phrase heard after the beep and to ignore the competitive story. The number of correctly repeated words was registered into the software to obtain the speech recognition threshold. All tests were performed in a silent room of a public school. Target sentences and competing histories were presented simultaneously in blocks of 31 sentences with rest in between. For the first block there was an extra 2 training sentences presented with a fixed 7dB signal-to-noise ratio (SNR). The remaining sentences were presented in an adaptive fashion. At the end of each block the Speech Recognition Threshold (SRT) was estimated.
Results**:** For each subject we discarded the training, calculated an average SRT, and used it to normalize each sentence's SNR. An ANOVA test on the subject's normalized SRT (nSRT) indicated that two subjects performed significantly different than the others and where, therefore, discarded. Then, for each sentence, we fitted a logit curve to the percent correct word by nSNR using least square regression. All sentences whose corrected coefficient of determination (R^2) was smaller than 0.5 were also discarded. For the remaining sentences we selected the 120 sentences whose nSNR needed to achieve 50% correct identification of words (a) and slope of the steepest portion of the curve (b) were closest, in an L_{inf} norm, to its median value, which resulted in $|a| < 1.9$dB and $0.28 < b < 0.78$. The selected sentences were adjusted in amplitude by $-a$ for equal intelligibility.
Conclusion**:** Research is ongoing and software and speech material are ready for application in the selected sample. It is hoped that the results obtained in this research may provide support for understanding the functioning of the central auditory nervous system structures involved in binaural interaction tasks, from the cochlear nucleus to the auditory cortex in Brazilian children. In addition, we hope to disclose the importance of studying spatial processing, especially in children with complaints related to hearing difficulties in noisy environments, to contribute for the diagnosis and help audiologists to plan a more fully and efficiently rehabilitation.

381 - The Communication Experiences of Tweens and Teens with Hearing Loss: The Impact of Advanced Hearing Aid Technology on Voice Emotion Recognition

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Children and teens with hearing loss, like their hearing peers, wish to learn, have friends, understand who they are, and feel they belong. in their school The purpose of this mixed methods study was to investigate the communication experiences of tweens and teens who wear hearing aids and look at the effect of advanced hearing aid processing strategies on that communication. Because no data exists on how children with normal hearing detect emotion in complex listening environments, emotion recognition abilities of 20 participants tweens and teens with hearing loss were compared to their age matched peers with typical normal hearing. This comparison occurred without the support of visual cues.
Participants were recruited from the Audiology Department in Auckland, New Zealand and the Hearing2Understand Hearing Clinic in Saskatoon, Canada.
Findings from this study could inform audiologists if emotion recognition is an area of concern for our deaf or hard of hearing tweens and teens. Last, there is an opportunity to learn about the communication environments tweens and teens value most and understand how their current hearing aid technology supports them.

459 - Neural Speech Tracking in Age Related Hearing Loss as a Function of Hearing Aid Use

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Age-related hearing loss (ARHL) is associated with difficulty understanding speech, particularly in the presence of background noise. Hearing aids do not (sufficiently) filter background noise, while the use of audio-visual (AV) speech cues contributes greatly to speech comprehension in noise. Nevertheless, the underlying neural processes of the facilitative role of visual speech cues is not well understood, especially in hearing aid users. The aim of this study was to investigate the effects of AV vs. audio only (A) listening conditions on neural speech processing in two groups of hearing-impaired older adults: 1) hearing aid users and 2) without hearing aid experience. To test neural speech processing, we used neural speech tracking, a measure that reflects the synchronization of low frequency auditory cortex activity with the temporal regularity of a continuous speech signal, which has been shown to be enhanced in ARHL and was correlated with better speech comprehension. Seventy-eight (N=78) subjects with ARHL (39 hearing aid users; 64 - 80 years; RangePTA = 31.05 - 59.6 dB, frequency range 0.5 to 8 kHz) were carefully matched by age and hearing loss and presented with natural sentences with noise (8 overlapping sentences, SNR = 0) in A and AV (showing speaker's mouth and chin) settings while EEG was recorded. An intelligibility task and a comprehension task were performed. Speech tracking will be estimated by cross-correlation, which assesses the similarity between two time series across time lags.
Using generalized mixed models, we showed that there is a significant improvement in both tasks for both groups as a function of visual cues. We also showed that individuals with hearing aids performed significantly better in the Comprehension Task, but significantly worse in the Intelligibility Task compared to individuals without hearing aids. In the next step we will include neural tracking (currently in progress) and investigate to what extent this effect is reflected in the tracking. We hypothesize that speech tracking will decrease as a function of hearing aid use, enhanced by AV information, which would suggest that the hearing aid partially substitutes neural compensation of ARHL. Answering these questions provides valuable insight for future optimization of hearing loss treatment, particularly the role of AV information in hearing aid implementation.

229 - To determine the psychological impact of hearing loss on soldiers offering services in conflict zones of Pakistan

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Introduction As we realize that soldiers operating in conflict areas are more vulnerable to listen excessive intensity of noise due to weapons. In Pakistan, past few years terrorism remained a terrific challenge for it's government, defense force and citizens. In many regions of Pakistan war against terror is carried out. In result of counter activities by armed forces, many solders lost their capacity of hearing. It will be a great study to check the psychological impact of these effected soldiers serving in war/conflict areas and to determine what services are providing by their department to make their better in term of hearing or coping with issues of hearing loss. I'm working in armed force post graduate medical institute and many employees of armed forces have been trained in the modules of PPHI so it will be easy and appropriate to do.
Study Design Case control study will be done by selecting cases from army personnel having hearing impairment due to exposure of explosive weapons or due to noise related to any source in services areas. Controls will be selected from army to having normal hearing functions. Cases can be traced back from registries of record from army department. Questionnaires will be structured to ask about by selecting a valid tool for psychological impact of hearing loss and will be filled and incorporated in data sheets. Odds ratios will be calculated and for numerical variables, linear regression will be applied and for categorical variables logistic regression will be used.
Conclusion The concluded results will be presented to the policy makers for providing services of rehabilitation to the person effected in order to rehabilitate the effected ones and to provide such equipment which prevent hearing loss in those who are nor affected yet.

15 - A study of Korean assessment of music perception(AMP) and music rehabilitation program(MRP)

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Introduction & Purpose: Music is an essential element to improve the quality of life as an non-verbal communication tool. It has been utilized for various aspects such as stabilizing emotion, developing auditory, language, cognitive, and motor functions. However, the hearing impaired(HI) has difficulty in listening to music which is influenced by decreased heairng sensitivity and temporal processing. To improve their quality of life, accurate assessment of music perception and music training are necessary. And the music training should be systematically conducted based on analytic and synthetic approaches like general auditory training. Therefore, this study aimed to develop the Assessment of Music Perception(AMP) and the Music Rehabilitation Program(MRP) based on Korean culture and emotion which can improve the music perception and enjoyment of the HI. Furthermore, comparison of the music perception ability before and after the music rehabilitation can provide the effectiveness of the MRP. Additionally, the objective measurement such as mismatch negativity(MMN) would give us better understanding concerning musical perception in brain.
Method***:*** The AMP was developed with six subtests which were pitch, melody, rhythm, timbre, emotional reaction, harmony perception tests. Pitch test was composed of six pure tones with low and high frequencies, 262, 330, 392 and 1047, 1319, 1568 Hz. Melody test was composed of ten songs including Korean folk songs. Rhythm test was composed of five rhythm patterns produced in different order of four quaver notes and four quaver rests. Timbre test was composed of ten western instruments and six Korean classic instruments. Emotional reaction test was composed of bright and dark emotional songs. Each of them was consisted of four Korean traditional music and four classical music. Harmony test was composed of major triad and augmented triad recognized as a representative chord and dissonance. The main training component of the MRP were developed with five elements including pitch, melody, rhythm, timbre, and musical emotion training. The pitch training was composed of three exercises which were ptich discrimination and identification, guessing of the pitch sequencing, and guessing of the pitch's number. The melody training was composed of two exercises which were melody pattern discrimination and identification, identification of the song's melody. The rhythm training was composed of two exercises which were guessing of the song's beat and imitation of the song's rhythm. The timbre training was composed of three activities which were learning instruments, timbre discrimination and identification, and guessing of the instruments' number. Lastly, the emotional reaction training was pursued to identify the musical intrinsic emotions. And also, to understand the realistic tendency for music, a questionnaire, Music listening Attitudes and Satisfaction Questionnaire (MASQ) was developed for two versions, MASQ_H for the HI and MASQ_G for the normal hearing. All the MRP were conducted to 15 cochlear implant(CI) adults whose average age was 34.5 years(SD±11.6). The MRP was executed twice per week through self-directed home training for two months. The AMP was tested before and after the MRP in a sound treated room to identify the effect of MRP. Additionally, MASQ, MRP effectiveness questionnaire and MMN were conducted.
Result***:*** The results of the AMP subtests were improved between pre- and post-tests. Especially, the pitch, timbre, and harmony perception test scores were showed significant difference. The correction rate of the pre- and post-test with 61.1%(±26.6) and 83.8%(±9.3) for the pitch perception test [$t(14)= -3.430$, $p<0.01$], 72.8%(±13.2) and 87.8%(±10.9) for the timbre perception test with Korean musical instruments [$t(14)= -3.535$, $p<0.01$], 48%(±14) and 59.3%(±12.8) with Western musical instruments , [$t(14)= -3.795$, $p<0.01$], and 55.9%(±18.8) and 71.1%(±17.8) in the harmony perception test [$t(14)= -2.423$, $p<0.05$]. Although there was improvement in melody, rhythm, and emotional reaction test, the difference was not significant. The correctioin rate of the pre- and post-test with 29%(±27.1) and 36%(±34.1) for the melody perception test [$t(14)= -1.098$, $p>0.05$], 95%(±9.1) and 98%(±3.2) for the rhythm perception test [$t(14)= -1.382$, $p>0.05$], and 85.8%(±14.8) and 88.3%(±3.9) for the emotional reaction test [$t(14)= -0.468$, $p>0.05$]. For the MMN test, the area of the waveform before and after MRP was 208.16 $\mu V \cdot$ms(±211.59) and 527.87 $\mu V \cdot$ms (±360.42) with the significant difference at 70 dB stimulation [$t(16)= -3.028$, $p<0.01$].

Conclusion***:*** After conducting MRP, the overall music perception ability in CI users was improved. Especially, the highest difference between pre- and post tests was found in pitch perception with 22% improvement. But the melody perception for CI users was found to be difficult to improve. Although the CI users responded that the melody was the most difficult components of the music, they wanted to improve melody perception mostly among other abilities. According to the MASQ_H and MRP effectiveness questionnaire, the CI users answered listening to music became very interesting after conducting MRP (46.7%). It was found that the CI users who participated in this study showed a strong desire to listen to music. Therefore, the music rehabilitation based on analytic and synthetic approaches should be conducted continuously to expand the range of the music experience and improve music listening ability for CI users. We speculated that MRP could help aural rehabilitation and the quality of life for the HI, as the music could contribute to the language and brain development that were proved through our study.

421 - Behavioral assessment and conditioned tonal threshold audiometry in children aged 0 to 4 years, what to expect?

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Introduction**:** child audiological assessment made great advances with universal neonatal hearing screening in the advent of otoacoustic emissions and brainstem evoked potential. However, we cannot overlook the importance of behavioral assessment and basic audiological assessment as instruments for better adaptation and rehabilitation of young children.
Objective: If it is possible to correlate chronological age with subjective auditory assessment procedures, behavioral and conditioned threshold tonal audiometry**.**
Results**:** 976 children aged from 0 to 4 years of age were evaluated, 69 (7.07%) children were between zero and 11 months of age; 140 (14.34%) between one year and one year and 11 months; 220 (22.54%) between two years and two years and 11 months; 262 (26.84%) between three years and three years and 11 months and 285 (29.20%) between four years and four years and 11 months. Children who underwent behavioral assessment were from 0 to 11 months old, 66 (95.65%), from one year and one year and 11 months old, 121 (86.43%), from two years and two years old and 11 months old were 138 (62.73%), those aged three years and three years and 11 months were 79 (30.15%) and those aged four years and four years and 11 months were 45(15.79%). The conditioned tonal threshold audiometry was for 0 to 11 months, 3 (4.35%), of those aged one year and one year and 11 months were 7 (5%), those aged two years and two years and 11 months were 82 (37.27%), those aged three years and three years and 11 months were 183 (69.85%) and those aged four years and four years and 11 months were 240 (84.21%). chronological age with the assessment procedures performed (behavioral observation audiometry and conditioned threshold tonal audiometry) it was concluded that the data obtained were compatible with the literature, demonstrating that in the first years of life the most performed test is behavioral observation audiometry, and as the child matures, conditioned tonal threshold audiometry becomes more prevalent.

443 - Parent-reported listening and communication skills in typically developing children

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Introduction: Some children may have diverse listening difficulties/auditory processing difficulties, e.g., in receiving, recognizing and interpreting sounds or speech. Such difficulties may be reflected in speech, language and literacy skills. This study evaluated parent-reported listening difficulties and communication skills and their associations in children with typical development.
Method: Voluntary participants comprised 40 children with typical development at the age of 5-8 years. Their listening and communications skills were assessed by Finnish versions of parental questionnaires ECLiPs and CCC-2. ECLiPS and CCC-2 total scores and subscale scores were calculated and their associations were analysed statistically.
Results: Preliminary results showed a median score 12,5 for ECLiPS and 102 for CCC-2. The median subscale scores of ECLiPS varied between -1,33---1,78, which correspond quite well the original scores given by Barry and Moore. For subscales median scores were 12,5 (speech and auditory processing), 11 (environmental and auditory sensitivity), 10,5 (language/literacy/laterality), 12 (memory and attention), and 13 (pragmatic and social skills). No statistially significant association was found between ECLiPS and CCC-2 total scores.

Discussion: Preliminary results in parent-reported listening difficulties of Finnish children showed similar results as obtained with original version of ECLiPS eventouhg the language was different. In this preliminary data, no significant correlation was found between ECLIPS and CCC-2 results. more studies are needed in order to see developmental trajectories of parent reporsted listening and communication skills in more detailed manner as well as connections between ECLiPS and CCC-2 scores in different age groups.
Keywords: auditory processing, communication skills, listening skills

140 - Auditory processing disorders in preterm born children of different ages

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Background: Very premature children are at high risk for hearing loss. However, even in the absence of peripheral hearing loss, they may have impaired maturation and formation of the auditory structures of the central nervous system. Along with acquired perinatal pathology of the brain, it is facilitated by disorders of its maturation and high vulnerability to adverse environmental factors. This may lead to speech and language delay, delayed cognitive development, problems with auditory memory, attention, academic difficulties, and generally reduce the quality of life.
Aims: Assessment of central auditory function in preterm born children of different ages by means of behavioral tests.
Patients and methods: 156 children were involved in the study: the study group consisted of 64 premature children (mean gestation age 28.2±2.2 weeks) and the control group included 92 term born ones. No child had peripheral hearing loss or ENT disorders. All children had normal hearing levels (pure tone thresholds less than 15 dB HL), normal immittance measures (both tympanometry and acoustic reflexes in uncrossed and crossed stimulus conditions), normal otoacoustic emissions and auditory brainstem responses. Three age subgroups were formed: 6-7 years; 8-9 years and 10-11 years. Central auditory testing included: random gap detection test (RGDT); duration patterns test (DPT); low-redundancy speech tests (monosyllabic words perception; the sentence speech audiometry (Simplified RuMatrix-test) in quiet and in noise using adaptive measures for determination signal-to-noise ratio providing 50% speech intelligibility, SNR_{50}); binaural fusion test (BFT); and dichotic digit test (DDT). A comprehensive case history was collected for each child. Parents of half of the premature children noted some auditory processing disorders (APD) symptoms in their children such as speech and language delay, learning problems, dyslexia, and/or difficulty learning a foreign language. All term born children demonstrated normal language, speech, cognitive, and academic development.
Results: 24 premature children (38%) completely failed RGDT. The test results for other premature children significantly exceeded the normative thresholds. Averaged indicators of correct answers of DPT were significantly worse in premature children of all ages compared to the control group ($p < 0.01$). The results of both tests revealed impairment of temporal resolution in premature children, which depends on the function of both brain hemispheres and auditory cortex, the state of the brain stem, and corpus callosum. Monaural intelligibility of monosyllabic words in quiet was normal for all children of all ages, but it was significantly worse for premature children of 6-7 years than for the control group in noise conditions. More than the half of premature children had impaired intelligibility in the Simplified RuMatrix-test compared to normative data and control group results. Averaged SNR_{50} values were -6.4±0.9 dB SNR for premature children of 6-7 years (-8.0±1.2 dB SNR normative data), -8.5±0.6 dB SNR for 8-9 years (-9.1±1.1 dB SNR normative data), and -7.8±1.01 dB SNR for 10-11 years (-9.4±0.9 dB SNR normative data). The performance of BFT was significantly worse in premature children aged 6-7 years old compared with the control group ($p<0.01$), the results of premature children of 8-9 years and 10-11 years did not differ from the control values. Results of DDT, which reflects the state of interhemispheric connections, of mainly the corpus callosum, were significantly worse ($p<0.01$) in the group of premature children compared to the control one for all ages.
Conclusion: APD may occur in premature infants even in the absence of peripheral hearing loss. Lesion sites seem to be multi-level; temporal processing, as well as the ability to dichotic listening could be disrupted to a high extent. Identified APD signs were not compensated by adolescence.
Keywords: premature children, auditory processing disorders, behavioral tests

372 - Influence of Early Visual Deprivation on Central Auditory Processing
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We evaluated whether there are differences in dichotic listening performance, auditory temporal sequencing ability and speech perception ability between early-blind subjects and sighted subjects. The study included 23 early-blind subjects (29.57 ± 5.03 years, M:F = 12:11) and 22 age-matched sighted subjects (28.59 ± 4.66 years, M:F = 11:11). A digit span test was performed to evaluate working memory capacity. Dichotic digit tests (three-digit pair) and frequency patterning tests (five tones) were performed to evaluate central auditory processing ability. Monosyllable perception in babble noise was measured under five signal-to-noise ratio (SNR) conditions (SNR −8, −4, 0, +4, and +8). In the dichotic listening test, the early-blind subjects achieved higher scores than the sighted subjects in the left ear ($p = 0.003$), but not in the right ear, indicating a right ear advantage in sighted subjects ($p < 0.001$) but not in early-blind subjects. In the frequency patterning test, the

early-blind subjects performed better (both ears in the humming response, but the left ear only in the labeling response) than the sighted subjects ($p < 0.01$). Monosyllable perception in noise tended to be better in early-blind subjects than in sighted subjects at a SNR of −8 ($p = 0.054$), the results at signal-to-noise ratio s of −4, 0, +4, and +8 did not differ. Acoustic change complex responses to /ba/ in babble noise recorded in the electroencephalography showed significant correlations with the behavioral results. Early-blind subjects exhibited some advantages in dichotic listening, temporal processing, and speech perception in noise compared with sighted subjects. These advantages may be attributable to the enhanced activity of the central auditory nervous system, especially the right hemisphere function, and the transfer of auditory information between hemispheres.
Keywords: Early visual deprivation; Speech perception; Monosyllable; Speech in noise; Visual cortex

452 - Relationship between the auditory capacity and Amplitude and Latency of P300 Wave in Adults with Normal Hearing
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Background and Aims: One of the most common auditory processing tests is Dichotic Consonant-Vowel (DCV) test. In this test, stimuli consist of six pairs of consonant-vowel (CV). Single CVs of each pairs are presented to each ear using a dichotic paradigm. Test items may be presented simultaneously or with 90 msec lag to each ear. Correct responses are scored in three manners: (1) right ear advantage (REA) by comparing right-ear scores to left ear scores, (2) lag effect by comparing scores obtained during 90 msec lag conditions to that for simultaneous presentation, and (3) auditory capacity effect by computing the double correct scores. In contrast to the first two scores, there is little information on double correct scores. The main purpose of the present study was to investigate the *possible* concomitance between double correct score and attention by P300 event related potential.
Materials and Methods**:** Participants consist of 37 normal hearing adults between 18 to 30 year-old. For each participants P300 response was recorded with non-inverting electrodes at two sites of Fz and Cz using oddball paradigm and subjects were asked to response the target stimulus by rising their fingers. DCV test was also, administered and double correct scores were computed.
Results**:** The recorded P300 amplitude was larger at Cz site. There was a significant correlation between double correct scores and amplitude of P300. Also, there was a weak but significant correlation between double correct scores and the P300 latency.
Conclusion**:** The findings suggest that there is direct relation between DCV double correct score and attention, also correct identification of dichotic stimulus may need the longer processing time.
Keywords: Auditory capacity; Event-related potential; Auditory attention; P300; Dichotic hearing; Central auditory processing

P.06 – COGNITIVE DECLINE AND DEMENTIA

34 - Hearing loss, social isolation and cognitive impairment: Epidemiology analysis on the Hertfordshire Ageing Study
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Aims: 1. To investigate an association between hearing threshold and later social isolation.
2. To investigate an association between hearing threshold and later cognitive impairment.
Background: Age-related hearing loss that is not managed appropriately can have a range of consequences that affect a person's health and wellbeing. There is evidence for an association between hearing threshold and social isolation, and hearing threshold and cognition. This is largely based on cross-sectional data. There is a need to tests these associations using longitudinal analysis to establish a temporal relationship and the

potential for causality. This could lead to greater understanding of unaddressed hearing loss consequences and help to improve the quality of life for older adults.
Methods: Data from the Hertfordshire Ageing Study (HAS) were used to investigate the above associations. The principal objective of the HAS is to examine life course influences on healthy ageing. The first HAS follow-up (time point 1) was conducted in 1994–95 when the participants ranged in age from 63 to 73 years (mean 67). This consisted of 717 participants who underwent pure tone audiometry (0.5-4kHz). Several confounding measures were also completed at this time point also, such as: age, gender, social class, smoking status, number of alcoholic units drunk per week, marital status, years of education, diagnosed angina, stroke, heart attack, high blood pressure, type 2 diabetes, and low mood/depression. At time point two in 2003-5, there was a high loss of attrition resulting in 294 participants who had completed measures at both time points. At this time, pure tone audiometry was repeated, along with the Mini Mental State
Examination and Social Support Index questionnaire.
Results: The average age of the study participants was 67 years at time point 1 and 76 years at time point 2. There were 294 participants in the final included sample and 59% were male, compared to 66.9% of males in the group who died. Univariate analyses were conducted for each confounder with the exposure and outcome variables. Multivariate linear regression was completed to test each association using an adjusted model, a model controlling for age and gender, and a model controlling for all confounders relating to the exposure and outcome variables. There was no association found between hearing threshold and later social isolation, and hearing threshold and later cognitive impairment. This remained so with a consistent participant sample (n=231) and weakened as more variables were controlled for.
Conclusions: This work highlights the potential for publication bias in the literature related to hearing and cognition epidemiology. There is also a need to consider the sensitivity of the cognition and social isolation variables used, and how these measures can be improved in future cohort studies.

5 - A systematic review to determine whether social isolation is a mediating factor in the association between hearing threshold and later cognitive function in adults

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Research Questions:

1. What is the association between hearing threshold and later cognitive function in adults?
2. Is social isolation a mediating factor in this association?

Social isolation has been associated with negative health outcomes throughout the literature, including increased risk of mortality in severe cases (Berkman and Syme, 1979, Berkman et al., 2000, Cohen, 2004). The social impact of reduced communication abilities can have a negative impact on quality of life (Balestreri et al., 2000). Older adults are particularly prone to this as the ageing process is accompanied by health conditions that affect one's communication such as hearing impairment and memory loss (Yorkston et al., 2010).
A systematic review to identify the associations between hearing threshold and later cognitive function is deemed necessary to provide meaningful conclusions to the recent surge in longitudinal analysis in this area. Although definitive mechanisms between hearing loss and cognitive decline/dementia have not yet been identified, there is evidence to support that an association is present (Lin et al., 2011), yet the factors that mediate this association have rarely been considered.
Electronic searches were performed in Web of Science, PubMed (Medline), Scopus, and ProQuest (PsychArticles and ProQuest Dissertation and Theses). Papers were critically appraised using the CASP checklists for cohort studies and risk of bias in the selected studies was assessed using the RTI item bank tool. Following the search of academic databases and grey literature, a total of 1589 articles were identified, of which 826 were duplicates. Full text screening revealed a total of 13 publications that were qualitatively synthesised based on the following inclusion and exclusion criteria:
Inclusion criteria:

- Longitudinal repeated-measures study
- Hearing threshold measured via pure tone audiometry at time point 1
- Measure of cognitive function at time point 1 or 2 and subsequent time points, and/or dementia diagnosis at subsequent time points
- Adult human participants >18 years

Exclusion criteria:

- Studies using self-reported hearing loss
- Studies using speech threshold testing
- Narrative reviews/commentaries

- Systematic reviews/meta-analyses
- Animal studies
- Dementia diagnosis at baseline

The synthesis of included studies indicates that an association does exist between hearing loss (moderate or greater) and later cognitive decline or incident dementia. However, the presence of social isolation as a mediating factor cannot be determined due to the lack of mediation analysis in all but one study (Alattar, 2019). Furthermore, it is difficult to accurately compare study findings when different statistical methods have been used to determine the presence and significance of associations.

Due to the range of cognitive measures used in studies to either assess cognitive capacity or confirm dementia diagnosis, it is not clear which aspect of cognition is wholly receptive to changes in hearing. The Mini Mental State Examination (MMSE) was most often used to assess global cognition that included attention, processing speed, and recall. Whilst this test displays high sensitivity, the combined cognitive components make it difficult to isolate the areas of cognition most affected. After MMSE, the Digit Symbol Substitution Test, a test of processing speed, was included most often in the battery of cognitive tests. Since problems with recall and processing speed are usually initial symptoms of dementia, these tests may be well suited to the detection of cognitive decline (Bamford et al., 2007). Tests of immediate and delayed recall were used by Gallacher et al (2012) and Anstey (2003), and Trail Making Test Part B (used to assess executive function) was used in Valentijn (2005), Armstrong (2018), and Alattar (2019).

Only a handful of papers have longitudinally analysed hearing and cognition data at appropriate time points to evidence a temporal relationship. There is still a need for further epidemiology analysis to be conducted where there is hearing data available longitudinally at several time points, alongside cognitive testing and/or dementia screening/diagnosis.

7 - Using Patient and Public Involvement (PPI) activities to identify research priorities and modify methods for research involving persons living with hearing loss and dementia

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Aims:

- To build and develop trusting relationships with care home managers, staff, residents, and relatives to enable a proposed ethnography and interviews to be carried out successfully for the purpose of contributing to hearing and dementia research
- To determine the importance and relevance of the proposed projects to the care home staff, residents, and their relatives

Our aim was to use PPI activities based on the NIHR INVOLVE framework to help inform research priorities and methods for a proposed ethnography, by establishing relationships with multiple stakeholders. Involving persons directly affected by conditions that are being researched, provide meaningful focus and direction to projects. The overarching approach of this work was derived from the relational skills model developed by Midwinter and Dickson (2015). Thismodel seeks to explain the five phases of relationship development, which follows a continuum of setting up the relationship to ending and maintaining the relationship. Empowerment is at the core of this model, and was therefore ideal to use marginalised communities (Egan, 2002). The person-centred nature of the model provides support in relationship development with the important stakeholders of a care home i.e. care home residents, relatives and care staff. By giving these marginalised communities a voice, the proposed research can be designed and disseminated in a relevant and respectful manner (British Geriatrics Society, 2011).

Research carried out in residential care settings is often challenging (Luff et al., 2011a). Not only is the researcher faced with reluctance of care home staff to participate due to high work pressures (Hall et al., 2009), they are also required to adapt to the community of the home very quickly in order to “fit in” as part of the team. When this is added to the high turnover of staff, the necessary preparations for conducting well-designed research can be difficult (Luff et al., 2011b). Building relationships (and trust) between different stakeholders of a care home should enable the research process to be more efficient and valuable (Froggatt et al., 2009). However, constant re-negotiation with the “gatekeepers” of research within those homes can delay the process (Luff et al., 2011b). Thus, investing time and effort into understanding the culture and context of the homes in which research is planned, can reap rewards in the relationships that are developed.

In order to determine feasibility of the proposed projects, to develop working relationships with care home staff, and refine research questions, an initial enquiry was conducted. This aimed to establish the importance and relevance of the studies from care home staff and residents affected by dementia. This was in addition to establishing likely methods, willingness to participate and developing partnerships in the research process. Four care homes within Birmingham, UK were initially visited to ensure they had the appropriate infrastructure to support the research.

As part of this PPI work, I spoke with staff members about the proposed research to find out their views on its relevance and importance, and to understand what was currently in place to help residents engage. Furthermore, I spoke with residents in an informal way about their experiences of living in care homes and what their daily activities usually consisted of, to understand the current level of engagement and satisfaction. The views of potential participants have informed the methods and approach of the proposed projects. This method of PPI has achieved the following:

- Established acceptability from care home staff and residents
- Negotiation of research timings according to staff schedules
- Refined research questions
- Realistic sample size targets
- Willing research sites with appropriate infrastructure
- Adaptations to recruitment and consent procedures

136 - Evaluation of a Swedish questionnaire for ecological momentary assessment of sound environments for older people with hearing impairment

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Background: The population of the world is expected to grow, with an increasing proportion of older people. The prevalence of hearing loss is almost two-thirds among people over the age of 70. Current research shows a relationship between hearing loss, cognitive impairment and dementia. A moderate hearing loss results in a 3-fold increase in the risk of dementia. In order to promote healthy aging, rehabilitation of older people with hearing impairment needs to be improved. Hearing aids often provide limited benefit in more difficult listening situations. In this research project, a Swedish questionnaire for ecological momentary assessment (EMA) of real listening situations is evaluated. The questionnaire is designed to provide a better understanding of the sound environments older people experience and how hearing rehabilitation for older people with hearing impairment can be improved. EMA is a method that allows data collection in real time, as the participants describe their experiences in their natural environment. This method has been shown to have high potential for use in clinical counselling and as a research tool.
Aims: The purpose of the current study is to evaluate a Swedish EMA, a smartphone-based survey of the perceived sound environment for older people with hearing impairment. The Swedish EMA questionnaire will later be used in the research study "Good auditory ecology for active and healthy aging", led by Professor Mary Rudner, Linköping University.
Methods: 15 participants, over the age of 65 will be recruited to the study from the Swedish National Hearing Association. Inclusion criteria are mild to moderate hearing loss, with or without hearing aids, no cognitive decline and active participation in listening situations on a regular basis. Complete pure tone- and speech audiogram data will be obtained. The Montreal Cognitive Assessment (MoCA) for screening participants cognitive ability, and the Hearing Handicap Inventory for the Elderly (HHIE) will be administered to all participants. The participants will complete the Swedish EMA survey under listening conditions of their own choice. The EMA questionnaire is based on previous EMA studies in English and German-speaking countries and is adapted for use in Sweden. It includes 14 questions targeting the participants experience in a real sound environment of mood, task difficulty, demand, motivation, loudness, listening effort, workload, performance, disability and frustration. Responses are given on rating scales. Semi-structured interviews with the participants will be held for evaluation of the EMA questionnaire.
Results of the study will be presented.

508 - Why Hearing Well Matters for Healthy Ageing. The Impact of Hearing Loss on Cognitive Health and Dementia

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A review of the most up to date evidence on the association between hearing loss, cognitive decline and dementia and whether better access to hearing aids, cochlear implants and other hearing technology could help attenuate cognitive decline and delay or prevent dementia was undertaken. The review found that as the ageing population grows, the numbers of those with hearing loss, cognitive decline and dementia are increasing leading to urgent public health and social issues. Over 60% of adults living with dementia will also have hearing impairment (Nirmalaseri et al 2017) and over 90% of adults living with dementia in aged care will have hearing impairment (Hopper et al., 2016).

Hearing loss in adulthood is linked to higher rates of unemployment, depression, greater cognitive decline, greater risk of falls, and comorbidities when compared with peers with normal hearing. In 2019 age-related hearing loss was the third largest cause of Years Lived with Disability globally, and the leading cause for adults older than 70 years. (World Report on Hearing WRH, WHO 2021) The additional costs associated with hearing loss in the UK are £30bn per year, and in France the Return on Investment for managing hearing loss was found to be 10:1. Providing hearing aids or cochlear implants has been shown to be cost effective.

Studies revealed a very strong association between hearing loss and dementia, however, professionals in these fields rarely interact to share expertise for these patients. Studies also show that those who have hearing impairment and dementia have greater communication impairment and poorer functional ability than those with dementia and no hearing impairment. (Guthrie et al, 2018; Slaughter and Bankes, 2007). Age-related hearing loss has been shown to be a potential risk factor for cognitive decline, cognitive impairment, and dementia and one of the most potentially modifiable (Livingston et al., 2020). Additionally, the costs of not addressing hearing loss and dementia have significant costs to society: cost benefit studies looking at hearing aid use with dementia patients showed that the cost benefit ratios were over 30 (Brent, 2018).

The review concluded that: A growing body of evidence suggests that those with hearing loss who use hearing aids may have a reduced risk of cognitive decline and other poor health outcomes than those who do not use hearing aids. Because past studies have not been randomized control trials it is difficult to know if those who self-selected to use hearing aids and cochlear implants have other characteristics that
may protect cognitive health.

There is also growing evidence which points towards Cochlear Implants having the potential to impact on improving cognition or at least arresting cognitive decline for key groups of CI recipients. This in turn would suggest that Cochlear Implants, and other hearing instruments, combined with appropriate cognitive rehabilitation could positively impact on the progression of dementia while not necessarily being able to reverse it. Managing hearing loss well in later life improves communication and independence, and reduces loneliness, social isolation and may help to alleviate cognitive decline and has been shown to be cost-effective for society. Investments in early intervention and early provision of hearing aids and implants will not only improve quality of life for older people, but will also save health systems additional medical and social costs in the future. Focusing on hearing loss presents major opportunities for health systems to invest in healthy aging and for the public to take action about their hearing, particularly as they age.

While future research is needed to better evaluate the mechanisms, hearing loss is the most important potentially reversible risk factor for dementia. (WHO, 2021; Livingston, 2020). Professionals, Health Authorities and those with hearing loss should be aware of this association.

The briefing paper from the summary calls for three actions:

Actions for governments

- National Action Plans on Hearing Loss
- Public Health Campaigns

National Screening Programmes for Hearing Loss

- National screening programmes for adults, improving early access to hearing aids and implants
- Sensitive to the association with dementia and cognitive decline
- Targeted screening in care homes, in homes

Training

- Training in identifying and managing hearing loss for those with dementia
- Interprofessional teams involved with the management of dementia and cognitive decline
- Supporting personal advocacy in management of hearing loss for those living with dementia

Addressing hearing loss in adults is a real opportunity to support healthy ageing for society.

Review available from CIICA https://ciicanet.org/wp-content/uploads/2021/12/CIICA-AND-EUROCIU-WHY-HEARING-WELL-MATTERS.pdf and www.euro.ciu.eu

P.07 – LISTENING EFFORT AND FATIGUE

341 - Listening Effort Correlates of Electromyographic Activity of Auricular Muscles
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For hearing impaired even using modern technologies ranging from hearing aids to cochlear implants, listening in challenging environments is still very effortful. This results in fatigue and withdrawal from social events. Because of this, there is an urge to develop better hearing technologies to reduce listening effort and verify its impact in an objective manner. The aim of this work was to investigate correlates of listening effort using the electromyographic (EMG) activity of three external ear muscles considered a vestigial orienting system in humans. For this, two auditory paradigms with different levels of difficulty were designed and presented via frontal loudspeaker placed to the subjects. The auditory task was to listen to a target story spoken by a female speaker while one or 2 distractors could be present. Thus, to reach different difficulty levels, one distractor spoken by a male voice was employed on the easy condition, and two distractors, one male and one female spoken stories were used for the difficult condition. The paradigms were tested in 17 normal hearing subjects. The EMG activity of the post-, superior and anterior auricular muscles of both ears was acquired as well as the subjective listening effort using a well-accepted rating scale. Electrooculography activity and EMG activity of the neck were also recorder for further artifact removal purposes. The experiment reached the expected subjective level of difficulty and the energy of the EMG activity from the auricular muscles showed an increment when increasing the level of difficulty of the auditory task. The results indicate that the vestigial pinna orienting system seems to be a useful tool for assessing the listening effort and deserves further research.
Keywords: Listening effort, auricular muscles

416 - Subjective and objective listening effort in newly implanted adult cochlear implant users: a novel virtual reality pupillometry setup
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Introduction Pupillometry as an objective measure of listening effort continues to gain popularity in the hearing research domain. Subjective measures of listening effort are still an emerging field and many confounding variables result in weak correlations with objective measures of listening effort [1, 2]. Regardless, discrepancies between listeners' perceived effort and physiologically indicated effort by measures of pupil dilation is of interest to eventually improve rehabilitation and performance. These discrepancies are stronger for bimodal cochlear implant (CI) users who have very different modes of stimulating the cochlea, i.e. a CI in one ear and a hearing aid in the other [3]. Here we investigate this discrepancy by objectively measuring listening effort with pupillometry and speech performance data in newly implanted adult CI users, while comparing these results to listeners' subjective reports of listening effort. It was hypothesized that pupil dilation and perceived listening effort would increase with increasing task difficulty, while speech perception performance would decrease.
Methods Pupillometry setup was implemented in a virtual reality (VR) head-mounted-display, with an integrated pupil recording system (Pupil Labs). The VR environment allowed for consistent control of luminance. Newly implanted adult CI users were presented with speech stimuli (Dutch matrix sentences) in the free field (S0N0) with varying signal-to-noise ratios. During the task the participants were instructed to focus on a red fixation dot that was present with a grey background. The task was carried out in both the CI-only condition and fully aided condition (bimodal). Pupil dilation and speech recognition was recorded for each signal-to-noise ratio that consisted of ten trials. Participants were also requested to rate their listening effort on a scale of 0 (no effort) to 10 (extremely effortful).
Results Data collection for this study is ongoing. A total of 20 adult CI candidates have consented to participate. At present, 4 newly implanted adult CI users have undergone listening effort assessments, with the remainder scheduled for 2022. Preliminary results of all participants who have undergone testing will be presented at the conference.
Conclusion Measures of listening effort can provide greater insights into clinical outcomes, such as post-implantation speech recognition and the underlying binaural mechanisms of speech recognition. Correlation

between physiologically measured and perceived listening effort, as well as their relationship to speech performance, are important for counselling, expectation management and clinical management of adult CI users.

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Keywords:

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92 - The effect of tinnitus maskability on the amount of listening effort: a pilot study

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Objective Chronic tinnitus can result in comorbid distressing symptoms, one of which is related to impaired concentration attributable to difficulties with speech understanding in various listening conditions. Previous research stated that non-auditory central aspects, such as working memory and selective attention, may influence hearing and speech understanding in several listening situations. Therefore, speech intelligibility may become more effortful for persons with tinnitus because their cognitive reserve is reduced by it. A pilot study showed significantly more listening effort in normal-hearing young adults with tinnitus compared to a control group (Degeest et al., 2017). It was hypothesized that an attention shift towards tinnitus and an extra load on working memory may reduce cognitive capacity when performing several tasks. Tinnitus patients may, however, profit from background noise to mask their tinnitus which, in turn, might result in less attention towards the tinnitus. In this respect, measuring the residual inhibition (RI) response is a useful technique to further explore this effect of maskability. RI is defined as a temporary tinnitus suppression or elimination following specific auditory stimulation. Therefore, the present pilot study aims to evaluate the effect of tinnitus maskability on listening effort.

Method Two groups of 5 tinnitus patients, categorized based on their RI response (i.e. (partial) positive or negative response) are included and compared with a control group. All subjects are matched for age, gender, hearing thresholds and educational level. Listening effort was evaluated using a dual-task paradigm. This paradigm consisted of a primary speech-recognition task in different listening conditions (i.e. quiet, SNR +2dB, and SNR -10dB) and a secondary visual memory task that were performed both separately and simultaneously (Degeest et al.2015). Listening effort was calculated as the change in visual memory performance from the baseline to the dual-task condition.

Results In the favorable listening conditions (i.e. quiet and SNR +2dB), the subjects with tinnitus and a negative RI tend to expend more listening effort compared to the control group. In contrast, the amount of listening effort in the subjects with tinnitus and a positive RI was comparable with the control group. Considering the unfavorable listening condition with a SNR of -10 dB, a trend was observed whereby both subjects with tinnitus and a negative RI and subjects with tinnitus and a positive RI expend more listening effort compared to the control group.

Discussion and conclusion This study was a pilot study to primarily assess the effect of tinnitus maskability on listening effort. Insights obtained by this study will be used to further elaborate research regarding tinnitus maskability and listening effort. In general, the results of this study showed that tinnitus maskability may influence the amount of listening effort, especially in more favorable listening conditions. Further research with a larger study sample, however, is necessary. Besides, inclusion of a comprehensive cognitive test battery to evaluate the effects of tinnitus on cognition is needed. Also, the evaluation of different types of masking noise (i.e. intermittent vs. continuous noise) would provide more insight into this area.

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390 - Evaluation of a behavioral test for listening effort: the effect of different types of speech stimuli and background noise

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Objectives Listening effort can be defined as the attentional and cognitive effort to understand speech (Bourland Hicks & Tharpe, 2002; Pichora-Fuller et al., 2016). There are several techniques to evaluate listening effort, which can be generally classified as subjective, behavioral, and objective measures. In order to evaluate listening effort behaviorally, a dual-task paradigm can be used, which consist of a primary and secondary task that have to be performed both separately and simultaneously. A Dutch dual-task test for listening effort was developed and used in several populations such as subjects with tinnitus, subjects exposed to noise as well as older adults (Degeest et al. 2017, 2021; Kestens et al., 2021). Based on these studies as well as literature, it was indicated that listening effort is a derivative of the auditory-cognitive processing of speech whereby the amount of exerted behavioral listening effort reflects all challenges related to a specific listening condition, including external environmental and internal listener's characteristics. The aim of the present study was to re-evaluate the current Dutch dual-task test pertaining to the external environmental factors. First, previous studies (Degeest et al. 2017, 2021; Kestens et al., 2021) showed that an unfavorable listening condition (e.g. signal-to-noise ratio (SNR) of –10 dB) represents a more challenging listening situation as compared to real-life situations, whereby such challenging conditions would usually be avoided by a person in real-life. Hence, the present study will consider listening conditions that are representative for real-life situations. Besides, these real-life listening conditions will also involve the use of different types of background noise; i.e. a steady state noise and an international multitalker babble noise. Second, the type of stimulus used for the primary speech-recognition task can influence the amount of exerted listening effort. More specific, contextual cues may be an important factor. Therefore, in addition to the evaluation of representative real-life listening conditions, the present study will compare the currently used monosyllabic digits with bisyllabic words.
Method The study included 100 adults between 18 and 65 years of age. Only subjects with gender- and age-corrected frequency-specific threshold norms according to ISO 7029 (International Organization for Standardization, 2000) are included. Hence, their hearing status is evaluated using tympanometry and pure-tone audiometry. Further, the subjects were required to have no history of communication or learning problems, nor known neurological disorders. Adults aged 60 years or older were screened using the Montreal Cognitive Assessment (Nasreddine et al., 2005) in order to exclude various cognitive impairments.
Listening effort is evaluated using a dual-task paradigm, consisting of a primary speech-recognition task in different listening conditions (i.e. a quiet listening condition and several noise conditions with a SNR of -4, 0, +4, +8 and +10 dB) and a secondary visual memory task that have to be performed both separately (i.e. the baseline condition) and simultaneously (i.e. the dual-task condition). Listening effort is calculated as the change in visual memory performance from the baseline to the dual-task condition. Each participant will perform the dual-task paradigm with two types of speech stimuli (i.e. digits and bisyllabic words) as well as two types of background noise (i.e. steady state noise and multitalker babble).
Discussion and conclusion The data collection is finalized and all data will be analyzed using several appropriate paired statistical measurements (e.g. repeated measures ANOVA or mixed-design ANOVA). Results of this study will be presented at the HEAL conference.

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389 - "I'm not lazy, I'm exhausted!" Developing a measure of cognitive, social-emotional and physical fatigue for Deaf and Hard of Hearing (D/HH) students.

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Classrooms comprise an ongoing array of cognitive, visual, auditory, and attentional demands. Students who are Deaf or Hard of Hearing (D/HH) must navigate these auditory and visual demands for up to six hours a day, five days a week. The increased effort and exertion needed to learn contributes to greater levels of cognitive, social emotional and physical fatigue that is compounded when students are denied resources known to minimize fatigue.
Fatigue in educational settings for students who are D/HH is poorly understood by both students and educators. Students often disregard fatigue symptoms or internalize the causes, have limited or maladaptive coping strategies, and minimize the serious consequences these actions have on their learning and academic success. Teachers frequently misconstrue ineffective coping behaviours as a lack of motivation or laziness, and often fail to recognize the importance of educational supports moderating cognitive, auditory, and visual exertion.
Thus, our goal is to provide a means for D/HH students and their educational team to understand the impact of fatigue, to advocate for appropriate supports (strategies and programs) in order to moderate fatigue in educational contexts. This presentation will discuss the first phase of this research program, designing the *Fatigue in Educational Contexts (FEC)* survey. The purpose of the survey is to accurately identify, describe, and interpret the presence and intensity of fatigue, and inform alleviation approaches.
There are currently few fatigue surveys available, and most examine workplace or injury related fatigue in adult populations. There are no fatigue instruments designed for dual-language users (spoken language and signed language) related to classroom environments.
In this poster we will describe the process undertaken to develop and create the FEC survey.
CHANGE TO PAST TENSE

1. Conducted focus group interviews with D/HH experts, specifically D/HH post-secondary students; parents of D/HH students; and D/HH professionals (e.g., teachers and clinicians). These expert groups provided complementary perspectives, experiences, and knowledge related to fatigue.
2. Knowledge gained from interviews was used to create a draft version of the FEC survey.
3. D/HH experts completed the survey.
4. Conducted focus group interviews with our D/HH experts to examine the survey for congruency between participant perspectives and the survey items, item wording confusions, and item redundancies.
5. Revised the FEC based on expert feedback, enhancing credibility, reliability and validity of the survey for our Phase 2 study.

Initial findings indicate that fatigue is a large issue that is affecting the overall wellbeing of students who are D/HH both academically, socially and physically. Therefore, the creation of the FEC will spearhead future research, raise awareness of fatigue as a threat to educational, social, and vocational outcomes for students who are D/HH and hopefully contribute to more reflective classroom practices.
Keywords: fatigue assessment; deaf or hard of hearing; survey development; educational settings

P.08 – AMPLIFICATION, TECHNOLOGIES AND STRATEGIES

36 - The development of a cognitive test protocol in order to optimize the hearing aid benefit: does visual or verbal cognitive testing matter?
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Objectives: Hearing aids are the primary rehabilitation devices to compensate for presbyacusis, though different results regarding aided performances are documented. Modern digital hearing aids are mainly fitted based on auditory outcomes, regardless the more complex high-level cognitive functions important for speech understanding. Hence, it is suggested that the differences regarding hearing aid benefit may be due to intersubject variability in the interaction between low-level sensory processes and high-level cognitive systems. In this respect, an auditory-cognitive test protocol was developed within our research group. However, two questions arose: (1) are the outcome parameters sufficiently sensitive to differentiate between good and poor

cognitive performances and thus, are these tests implementable in audiological practice, and (2) does a difference in cognitive construct appears between usage of visual and verbal test items.
Material and methods: One-hundred eighty-four participants aged between 18 and 69 years were included. All participants showed age-appropriate hearing and did not report tinnitus, learning disorders, attention deficits, or neurological disorders. The backward corsi tapping task was performed to evaluate working memory and processing speed visually, whereas the letter-number sequencing task was used to evaluate working memory and processing speed verbally. For both tests, working memory was determined by three outcome parameters: (1) span length (i.e. longest correctly remembered sequence), (2) raw score (i.e. number of correctly remembered trials), and (3) product score (i.e. compound score of span length and raw score). At each span length, the fastest processing speed out of the correctly solved items was determined and used in further analyses. Descriptive and univariate analyses were performed to evaluate the effect of age and sex on all measured outcome parameters. Moreover, correlation coefficients were computed to evaluate the relation between visually and verbally measured outcomes for each cognitive function separately.
Results**:** For all outcome parameters, a decrease in performance was observed with increasing age. For visual and verbal working memory, males performed better compared to females, whereas no clear sex effect was observed for visual and verbal processing speed. Significant correlations between visual and verbal outcome parameters were found for working memory and processing speed up to span length four. However, only small-to-moderate correlation coefficients were observed.
Conclusion**:** The backward corsi tapping task and letter-number sequencing task seemed implementable in audiological practice. Moreover, a difference in construct validity between visual and verbal testing was suggested. Future research should focus on examining the relation between speech understanding, and the backward corsi tapping task and the letter-number sequencing task, in order to determine whether visual or verbal testing is preferred to be implemented in an auditory-cognitive test protocol..
Key words: working memory, processing speed, auditory-cognitive testing, speech understanding, visual testing, verbal testing

422 - Challenges in the assessment and fitting of hearing aids in children with multiple disabilities
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Introduction**:** Hearing loss affects a significant number of the world population and, according to the Gallaudet research institute, around 30% to 40% of children with hearing loss may have one or more additional deficiencies, hence the importance of this topic both for the evaluation and for the rehabilitation of these children. The audiological assessment and rehabilitation of children with hearing loss associated with other impairments is a matter that deserves attention. First of all, the diagnosis of multiple disabilities depends on a qualified team. Children with multiple disabilities have characteristics that distinguish them from others, such as attention difficulty, more time to respond, involuntary body movements and others that demand an experienced and accurate look. Factors such as age and degree of hearing loss guide the choice of exams and the respective methodologies needed for each exam. According to the chronological age and the level of development, the audiological evaluation and the adaptation of hearing devices require extra care. Objective**:** Present three cases of children with multiple disabilities, including audiological assessments and performance of Hering aids. Method: audiological evaluation, monitoring of the use of hearing aids recorded using the datalog algorithm. To assess the benefit and performance, the PEACH questionnaire was applied (Ching, Hill, 2007). After this stage, four meetings were held with the parents, each lasting one hour and thirty minutes**.** Results and discussion: Sight and hearing are our two senses of distance and are what we predominantly use to perceive and understand the world, to interact and communicate. Thus, the double sensory loss of deafblindness can greatly affect the development and learning of the subject, as it implies different problems of communication, mobility and access to information. Children with deafblindness need specialized transdisciplinary care for both assessment and appropriate follow-up, which in fact favors the development of their specific skills and their full potential. Children with ASD may exhibit hypersensitive or hypersensitive behavior to sounds, and further assessments are needed to make a diagnosis of associated hearing loss. Therefore, it is imperative to carry out a careful audiological evaluation, preferably with a warble tone and, in the speech perception test, to use favorite songs and always involve the parents. Conclusion**:** Considering that the assessment is the basis for the development of a stimulation program and that interaction and communication are essential for a good assessment, it is necessary to consider the collaborative work between professionals of a transdisciplinary team already in the assessment process. Due to the uniqueness of each child, one must believe in their potential and promote interventions centered on the family. The child must always be at the center, involved by the family, the transdisciplinary team and the school. Without the support of this group of people, the child can lose to evolve properly.

424 - Clinical Consensus for Fitting Non-Surgical Transcutaneous Bone Conduction Hearing Devices
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A clinical consensus document that addresses the assessment, selection, and fitting considerations for non-surgical bone conduction hearing devices (BCHD) for children identified as having unilateral or bilateral, chronic/permanent conductive or mixed hearing losses was developed by The Pediatric Bone Conduction Working Group. The group is composed of audiologists from North America who have experience working with BCHDs in children. The aim was to provide clinical direction for an area of pediatric audiology practice that is under development and is therefore lacking in standard protocols or guidelines.

272 - Use of GN Multi mic in place of FM/radio aid within a classroom setting and within day to day home use for children with longstanding hearing loss
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Background In the UK FM systems are widely used in schools for children with hearing loss and often offered to children with hearing loss. FM (frequency modulation) uses radio waves to transmit audio signals to the listener. Within schools, teachers will often have a microphone around their neck which is connected to a transmitter which sends a wireless audio signal to a receiver. The receiver (shoe) is worn by the listener and is often attached to a hearing aid.
The GN ReSound Multi Mic is a wireless streamer from GN ReSound that can stream speech and audio directly to a GN ReSound compatible hearing aid(s). Using 2.4 GHz wireless technology it is able to do this discreetly and without the need to wear an additional streaming device around your neck. Streaming refers to transferring data so that is can be processed as a steady and continuous stream in turn improving the signal to noise ratio (Kim and Kim, 2014). We wish to see how a wireless streamer would work in a classroom setting and within different day to day situations.
Aims
- To evaluate patient experience of the GN Resound Multi mic in a classroom setting as well as an extra-curricular setting
- To evaluate patient experience of the GN Resound Multi mic in a home setting
- To evaluate the use of the GN Resound Multi mic in day to day situations

Participants
Participants are 3 paediatric patients who have longstanding bilateral sensori neural hearing losses. All 3 patients have previous of a radio aid/FM system in school.
Inclusion criteria
- Experienced and long-term users of FM/radio aids in school
- Experienced and long-term users of hearing aid
- Aged 7-12 years

Exclusion criteria
Children with any additional needs
- Short term users of hearing aids

Methodology
The study will require the participant to be using the most current model of GN hearing aid in order to allow compatibility with the GN multi mic. If the participant does not currently wear GN aids we will fit these. The timeline for study is below:

- Initial bilateral fit to GN hearing aids which will be paired with the multi mic.
- Six week follow up: to check progress with hearing aids and multi mic but also complete any fine tuning that may be required.
- Further six week follow up: final review of the multi mic and hearing aids
- Parents will be asked to complete questionnaires throughout the trial to help meet the aims of the study.
- We will also assess the participant's ability to hear speech with speech testing. In this instance using the Manchester Junior Wordlist in both quiet and noise. This has been used in order to assess how well the child is able to discriminate speech sounds with the aids before use of any additional listening devices

Outcome measures

- **Listening Inventories for Education UK Individual Hearing Profile (LIFE UK – IHP)**
- **Parents Evaluation of Aural/Oral Performance of Children and Ease of Listening (PEACH +)**
- **Listening Inventory for Education (revised) Teacher Appraisal of Listening Difficulty (LIFE-R)**

All questionnaires are to be completed by participants at before the trial, at the six week review and at the final review. Any all subjective feedback from parents, teachers and participants throughout the trial will also be documented and analysed. A final questionnaire requesting subjective feedback from parents, the participant and teachers will also be designed and analysed. This is to determine the overall experience of the multi mic at home, school and extracurricular activities.

Results: We aim to complete the trial in April 2021 and will collate data and findings after these final reviews. (Appointments were delayed due to national lockdowns and school and departmental closures as a result of this).

Keywords: GN Multi mic, FM/radio aid, streamers

444 - Speech awareness improvements with dual-streaming technology for people with single-sided deafness

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Single-sided deafness (SSD) is common, with an estimated prevalence of 1% of the general population. This equates to approximately 60,000 Americans or 9,000 Britons being affected on a yearly basis.

One treatment option for suffers of SSD is using a Contralateral Routing of Signal (CROS) solution which routes the signal from the poorer ear side to the better ear. In 2019, Oticon released a new CROS solution for people with SSD that included dual-streaming technology – a first in the industry. This means that CROS users are now able to listen to a streamed signal in the better hearing ear (from for example a mobile phone), while at the same time receiving the transmitted signal from the poorer side.

An internal study was undertaken that focused on this unique ability to stream two sound sources simultaneously and how this could benefit the user. In the study, the outcome measure was speech awareness on the poorer ear side during streaming from an external source. It was hypothesized that test subjects would be significantly more aware of the target words when the transmission of sound via Near Field Magnetic Induction (NFMI) was active versus inactive, all the while listening to a main sound source from the ConnectClip remote microphone accessory.

The overall results from the study showed a 50% improvement in speech awareness when transmission was active during streaming from an external source. This means that CROS/BiCROS users can benefit greatly from having access to speech information in their environment, also while streaming. The test methods, conditions, results, and conclusions will be covered during this presentation.

Keywords: CROS, dual-streaming, Bluetooth, NFMI, speech awareness

P.09 – COCHLEAR IMPLANTS: STATE OF THE ART

318 - Effect of auditory feedback on speech intelligibility of adults with cochlear implants

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Purpose This study examined the effect of auditory feedback on the speech intelligibility of adults with cochlear implant (CI). In addition, to evaluate which speech characteristics: general level speech intelligibility, pitch, nasality, harshness, breathiness, fluency, hesitations, omissions, substitutions or disruption of constants and vowels, and intonations are affected the most by the hearing impairment and which are affected less. Additionally, to evaluate the relationship between age of implantation, with speech intelligibility using the CI.
Method Twenty young adults (age 19-29) with CI participated in our study; all subjects in the study had pre-lingual hearing impairments and received implants at the age of 2-19 years. A demographic questionnaire was completed. The subjects were asked to read excerpts from a book and word lists from MIDBAR test (bi-syllables) in two situations - with and without the using the CI. Sixteen judges, listened to the word lists and wrote the words as they heard them; in addition, they rated the speech intelligibility and speech characteristics of the subjects reading the excerpts using an adapted version of speech intelligibility test (SIR) and Intelligibility Questionnaire for Teachers.
Results The results indicated a significant difference in the speech intelligibility of words of subjects implanted at a young age. No auditory feedback effect was found for those implanted before age three. The speech characteristic most affected by the hearing impairment is the disruption of consonants followed by the varied degrees of intonation precision and nasality.
Conclusions Auditory feedback is vital to speech intelligibility. The different speech characteristics affected auditory feedback differently. The use of the MIDBAR can be a useful clinical tool in assessing speech intelligibility and habilitation of young adults with cochlear implants. Further studies of auditory feedback on speech intelligibility in subjects who were implanted prior to the age of two is warranted.

413 - Auditory, visual and cognitive abilities in relation to cochlear implant outcome in elderly

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Introduction: Cochlear implantation (CI) is the standard-of-care for individuals with severe to profound hearing loss. Nowadays, there is an increase in the number of older patients among the post-lingual hearing-impaired candidates for CI. Within this elderly population, a large variation in the degree of CI benefit has been reported, especially pertaining to speech understanding. It is suggested that the variation in speech understanding may not solely be due to peripheral auditory factors. Speech understanding is considered a multisensory process, whereby visual information (e.g. from mouth movements) is integrated with auditory information in order to increase intelligibility [1]. Besides visual information, also cognitive functions (i.e. top-down processes) are involved in speech processing. More specific, working memory, processing speed, selective attention, as well as cognitive flexibility and inhibition are required for speech processing [2], especially in unfavorable listening conditions (e.g. background noise, hearing impairment or listening through a CI). Therefore, the aim of the current study was to identify various factors, including auditory, visual and cognitive factors, predicting CI outcome in elderly CI users.
Methods: Five elderly CI users with a severe to profound post-lingually acquired hearing loss were included in this study. Age ranged from 71 to 79 years (mean 76.0 years, standard deviation 3.60). For all participants, auditory, visual and cognitive abilities were investigated behaviorally and subjectively. The auditory test battery consisted of pure-tone audiometry, speech audiometry in quiet and in noise. The visual speech processing abilities were evaluated using the Test for (Audio-)Visual Speech Perception (TAUVIS) [3]. For evaluating the cognitive abilities, all participants were first screened for mild cognitive impairment using the Montreal Cognitive Assessment (MoCA) [4]. Besides, the subtest 'Repeating Digits and Letters' from the WAIS IV-NL [5] was used to measure working memory capacity and processing speed. Selective attention, and cognitive flexibility and inhibition, were investigated using the subtest 'Letter Detection' from the Cognitive Test Battery for Seniors [6] and an auditory Stroop test [7], respectively. The subjective impact of hearing loss on quality of life was investigated using the hearing-related quality of life questionnaire for Auditory-VIsual, COgnitive and Psychosocial functioning (hAVICOP) [8]. The contribution of the auditory, visual and cognitive abilities to speech understanding in quiet and in noise will be investigated using linear regression analyses.
Results and conclusions: This study aimed to identify the contribution of auditory, visual and cognitive factors, to CI outcome in elderly. It is hypothesized that specifically the contribution of the cognitive abilities could be responsible for the variation in speech understanding outcome in elderly CI users. Currently, data collection is still ongoing, and the results will be presented at the HeAL conference 2022.
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212 - The dynamic 'ears' of bees; towards directional hearing with fully implantable microphones

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Rationale Understanding the unique properties of the hearing organ of bees provides fundamental evidence on how to obtain and process directional information when only very limited intensity differences and time delays are present. Johnston's organs, on the bee's antennae, have intrinsic directional sensitivity and, in addition, allow for active scanning movements.
Objectives We aim to answer the question whether honeybees and bumblebees actively move their 'ears' to obtain optimal directional sensitivity, and we will examine to what extent active 'ears' are able to discriminate acoustical signals produced by their own wingbeat, from sounds produced by predators and other species.
Methods Coevolution of bees and flowers has generated more than 20.000 species of bees, among which the well- known honeybees and bumblebees. Bees have remarkable auditory skills, based on six 'ears'. Two of them, called Johnston's organs, are located at the second segment of the antennae. They are sensitive to low frequencies (250-280 Hz), corresponding to the frequency of their wingbeats. Despite the small size of bees compared to the sound wavelength, bees can easily be trained to localize artificial sounds. With 'ears' on mobile antennae, bees are able to move their 'ears' closer and further apart, which potentially enhances directional sensitivity for sounds, for example generated by predators or echoes of their own wingbeat. We will study sound discrimination performance using high-speed, high-resolution cameras, in both honeybees and bumblebees subjected to artificial sound stimuli. Experiments are performed in the laboratory and in free field.
Results Movies of the movements of the antennae of bees and preliminary data regarding their 'dynamic ears' will be presented.
Conclusions No conclusions yet while writing the abstract. In the end, the fundamental knowledge obtained will be used in biomimetic applications aimed at developing fully implantable hearing implants, with a microphone in the earlobe that utilizes active directional scanning.

P.10 – SPEECH PERCEPTION / SPEECH DEVELOPMENT

223 - Auditory function in children with speech delay

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Early diagnosis of hearing impairment is crucial in a child's development. It is known that children with mild to moderate hearing loss may have speech disorders due to insufficient perception of information. Speech is the most important psychological process formed in the first years of life. Speech delay is the strongest pathological factor that has an extremely negative impact on the child's mental, emotional, cognitive and social development. The reasons are many-sided. Pediatricians, neurologists, and speech therapists actively refer children with speech delay for examination by otorhinolaryngologists and audiologists to exclude pathology from the auditory system as one of the possible causes of speech pathology.
In the period 2018-2019, we performed outpatient examinations of 72 patients aged 2 to 4 years, who were referred by a pediatrician, neurologist or speech therapist to an otorhinolaryngologist with speech delay to rule out hearing impairment. All 72 children (100%) underwent tympanometry, otoacoustic emission and registration of auditory evoked potentials. Despite the fact that 22 children (30%) had normal hearing, the majority - 45 children (63%) a conductive component of hearing loss was detected due to the presence of concomitant pathology of the lymphopharyngeal ring with the usual formation of auditory tube dysfunction or the presence of otitis with effusion, and 5 children (7%) were sent for hearing aid fitting.
Thus, an interdisciplinary approach to management of children with speech delay using generally accepted algorithms for examination patients with suspected hearing impairment is necessary to detect hearing loss and deafness, as well as concomitant pathology of ENT. At the same time, thanks to modern and timely methods of hearing screening, it is possible to start early speech rehabilitation in patients who do not need the supervision of an ENT specialist.

102 - The structure and type of sentences in written speech in hearing-impaired children

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As a consequence of the auditory analyzer hypofunction in hearing-impaired children the analysis and syntesis of verbal acoustic stimuli are disabled or restricted, which is an impediment to the normal development of oral speech. Disturbed auditory perception also affects written speech which, as a symbolic means of communication, in new circumstances develops in a specific way.
The aim of this research is ascertaining the structures and types of sentences in written speech in hearing-impaired children depending on the degree of hearing impairment.
A sample of 40 hearing-impaired children from the higher grades of elementary schools on the territory of the City of Belgrade is encompassed by the research. The sample is divided into two groups: Group A – the children with severe hearing loss; and Group B – the children with profound hearing loss. The sample is equalized regarding the age, the degree of hearing impairment and intelectual abilities.
The instrument applied in the research is the Informal Test of the Free Written Composition.
The research findings show that Group A have better results regarding the structures and types of sentences in written speech compared to Group B. The children with better hearing remnants (Group A) have the greater use of expanded and complex sentences, as well as the total number of sentences compared to the children with profound hearing loss (Group B), whose sentences are meager, with the small number of used words, and often incomplete.
Group A use declarative, interrogative and exclamative sentences in contrast to Group B, who exclusively use declarative sentences. Group B express themselves more statically and confusedly through their sentences, and with more unclarities and examples of agrammatism compared to Group A.
The conclusion is that the structure and type of sentences in written speech in hearing-impaired children directly depend on the degree of hearing impairment.
Key words: sentence structure, sentence type, written speech, hearing-impaired children.

446 - Long term effects of early age at cochlear implantation on metaphor comprehension and executive functions in Swedish teenagers

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Long term effects of early age at cochlear implantation on metaphor comprehension and executive functions in Swedish teenagers.

Introduction: Early age at cochlear implantation (CI) in congenitally deaf children has positive effects on early spoken language by reducing the period of auditory deprivation. There is still an urgent need for more research on the long-term effects of early implantation to explain the large variability in outcomes seen in this group. The research regarding long term effects of cochlear implantation on higher linguistic skills, such as figurative language, is scarce. Metaphor comprehension is a figurative language skill that starts to develop early in childhood. The mechanisms behind understanding metaphors have not been fully explained but core language skills are of importance.

Executive functions are higher cognitive functions including working memory, attention shifting and inhibitory control. Executive functions develop in close relationship with linguistic skills. Several studies have found deficits in the executive functions of children with different level of hearing impairment, including those with cochlear implants.

The aim of this project, as part of a multidisciplinary follow up program, is to investigate long term effects of early cochlear implantation on linguistic and cognitive outcome in a Swedish cohort of adolescents. We aim to contribute to the knowledge on the role of age of implantation in the development of executive functions and metaphor comprehension. We are also interested in the possible relationship between executive functions and the higher linguistic skill of metaphor comprehension. As indicated by previous studies we expect the group with CI to have poorer performance than the control group regarding metaphor comprehension as well as executive functions. Knowing that early age at 1st CI has positive effects on core language skills and cognitive processing, our hypothesis is that early age at CI will also have a positive effect on the understanding of metaphors at older ages.

Methods: The data collection is planned to start in January 2022. The cohort is estimated to be around 100 individuals between 12 and 19 years old, fitted with CI before 30 months of age. There will also be a normal hearing control group matched for age, sex and socioeconomic status.

Metaphor comprehension will be measured using a multiple-choice task with a verbal response adapted from Kalandadze *et al.*, 2021. Linguistic skills (vocabulary and reading) will be assessed using standardized test. Executive functions will be assessed by task performance (serial recall of nonwords, reading span and trail making test) as well as self and parent report by the BRIEF questionnaire.

Children from multilingual as well as monolingual homes will be included in the study. This gives us the possibility to compare core language skills, metaphor comprehension as well as executive functioning between multi and monolingual subgroups.

Results: Preliminary results related to linguistic and cognitive outcome will be shared in the presentation.

Key words: early cochlear implantation, linguistic development, figurative language, executive functions, teenagers

436 - Speech degradation effect on the detection and learning of novel words

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Background: Learning novel words depends on one's ability to first detect the novel phonological patterns and second to assimilate these new patterns together with the relevant semantic representation. A degraded speech signal is likely to challenge novel word detection by enhancing the lexical competition between the new input and other phonemically-close words, but also to challenge the assimilation of novel words by increasing the cognitive load required to maintain the uncertain word-forms in working memory while learning occurs. For Cochlear Implant (CI) users, who are only given access to underspecified acoustic cues, both novel word detection and assimilation are therefore challenging and could an explain slower rate of vocabulary acquisition.

Objective**:** In this project we investigate to what extent a degraded speech input affects the detection and assimilation of novel words in simulated CI, and how these processes relate to phonological discrimination and working memory capacity.

Materials and Methods**:** Nonwords derived from the Danish phonology were used for assessing phonological discrimination, phonological working memory, and as proxies for new word detection and learning in auditory modality [1]. The choice for nonwords, instead of real words, was made to reduce language knowledge effects. Previous nonword materials available in Danish, as the DANOK [2] and the PiTu [3], were used as source corpora. Additionally, a new corpus of 72 sentences with embedded nonwords was generated, using child-

level vocabulary [4]. For this first study, Native Danish speaking adults with normal hearing were included. The tasks were conducted in a computer-based platform, in two conditions: clear non-vocoded audio, and 8-channel noise-vocoded audio. Accuracy of nonword detection, average number of repetitions to nonword-assimilation, and response times were recorded.
Results**:** Results from paired analysis between the two conditions tested will be presented. Based on the initial data recorded, we expect that conditions that reduce phonological discrimination will impact the detection of nonwords as well as their learning rate. Moreover, we hypothesize that poorer scores in phonological discrimination will correlate with misses in nonword detection and lower speed of word learning. We also hypothesize that better scores in working memory tasks will be reflected as smaller differences between clear and vocoded speech conditions.
Conclusion**:** We anticipate that the patterns of nonword detection and assimilation from vocoded speech in normal hearing adults can serve the understanding of the dynamics of novel word learning in CI users. As a next step, we plan to replicate this paradigm with children with CI.
Keywords: speech perception, speech discrimination, learning, cochlear implant
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465 - Crosslinguistic perspectives on morphological development in children with hearing loss
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In children with any degree of hearing loss, there is an increased risk of problems with the acquisition of phonology and grammatical morphology. Despite indications that grammatical morphology is challenging for this population, there is a lack of research about how these challenges are manifested in different languages, as well as across different hearing device types. There is also a dearth of studies of to what extent children with hearing loss show patterns of development that are similar to those found for either normal hearing children or children with language disorders. Morphology develops in interaction with prosody and phonology, and successful use of grammatical morphemes is hypothetically dependent on the ability to handle complex phonological structure (Demuth & Tomas, 2016) and stress (Gerken, 1994). Since prosodic and phonological features vary across languages, it can be assumed that difficulties with speech and language due to hearing loss are realized differently across languages. The aim of the present study was to explore production of verbal and nominal morphology, as well as prosodic and segmental phonological production, in French-speaking and Swedish-speaking children with moderate hearing loss.
Participants were 13 monolingual French-speaking children and nine monolingual Swedish-speaking four–six-year-old children with bilateral sensorineural hearing loss who wore conventional hearing aids. The two groups were also comparable in terms of socio-economic status. The children completed tasks aimed to elicit grammatical production of verbal and nominal morphology. Their grammatical production, as well as their phonological production in the tasks, were analyzed using the CLAN and PHON softwares. The analysis focused on comparable verbal and nominal morphological elements in both languages, and on patterns of error as well as relative strengths.
The results revealed that there were several common difficulties between these two groups, but also that there were some differences regarding how similar grammatical constructions are handled. For example, the use of copula verb was easier for the Swedish-speaking children, whereas use of the modal future tense was easier for the French-speaking children. Results are discussed in light of theories that assume that difficulties with the perception and production of phonological and prosodic structure are part of the explanation for grammatical problems. The results have importance for our understanding of how hearing loss impacts language development in different linguistic environments.
Keywords: hearing loss, children, grammatical morphology, prosody, phonology

399 - How accurate and confident are clinicians at predicting one-year post-operative outcomes for adults with cochlear implants?

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Introduction**:** Unexplained variability in adult patient outcomes post cochlear implantation continues to be a prevalent topic for investigation. It is estimated that at least 10% of cochlear implant (CI) users receive sub-optimal benefit from their CI and are considered "poor performers" [1]. Current prediction models for post-CI speech perception outcomes have not yielded valuable clinical use for explaining outcome variability [2]. Furthermore, given the impact of individual etiological and medical factors on speech perception, focusing on speech perception in isolation when categorizing patients as good and poor performers, may not be the most holistic way to view post-implantation outcomes. This study takes a novel approach to outcome prediction by exploring whether clinicians hold more knowledge than prediction algorithms. The ability of the CI team to accurately predict "poor performance" versus "good performance" in adult CI candidates remains to be studied. This study investigated how accurately and confidently clinicians are able to predict one-year post-CI outcomes for adult CI users and which factors they consider to be important for outcome prediction.
Methods**:** Two 85-item surveys were sent out to audiologists, speech therapists and clinical technical specialists working with adult CI users. The surveys comprised of demographic questions followed by six anonymized clinical case studies. The anonymized case studies were based on existing cases from our Ear, Nose and Throat department and represented a wide range of outcome variation, determined by one-year post-CI speech perception outcomes. Information for each case study was provided for three time points: pre-CI, one-month post-CI and six months post-CI. For each time point, participants were required to use the information given to predict one-year post-CI outcomes, represented as a phoneme or word score (ranging from 0 – 100%) and to rate their confidence in their prediction (ranging from 0 – 10).
Results**:** This is an ongoing study for which data collection is still underway. At present, 121 clinicians have consented to participate. 88 clinicians have completed all demographic questions and have indicated which five factors they consider to be most important for outcome prediction, of which 30 have also completed all six case studies. Preliminary data analysis shows that, on average, clinicians over-predict outcomes for poor performers and that prediction accuracy does not significantly improve when more case information is provided.
Conclusion**:** Preliminary data analysis suggests that clinicians differ in their ability to accurately predict outcomes, both between timepoints in the same case study and across case studies. Of importance is clinicians' predictions of poor performance, which revealed large differences between predicted and actual outcomes. Accurate prediction is important for managing patient expectations and providing personalized pre-CI counselling, as well as to provide early intervention for CI users with poor performance or those at-risk of poor performance. With expanded indications for implantation, CI uptake has become more complex, resulting in increased outcome variation. Realistic patient expectations through appropriate counselling therefore becomes even more important for post-CI quality of life outcomes in adult CI users. Final results will be presented at the conference.
This study is part of the MOSAICS project that has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 860718.
Keywords: cochlear implant, outcomes, speech perception, prediction
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P.11 – e-HELTH AND m-HEALTH

346 - A mobile system for testing the perception and localization of binaural information in Infants (PLOBI2go)

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The development of hearing in children has a decisive effect on the development of speech. Social and emotional development processes also depend on healthy hearing. Currently, hearing in children up to school age is only examined at two points in time in Germany: approximately two days after birth (Universal Newborn Hearing Screening, UNHS) and then at pre-school age. This second hearing screening is carried out at about 4.5 to 5 years of age during the pediatric preventive examination "U8" and the publicly regulated school entrance examination (SEU). However, the current methods do not appear to be sufficiently suitable for detecting the age-typical hearing problems. Furthermore, there is disagreement in professional circles about the extent to which hearing impairment in child development can be tolerated or from which extent or duration therapeutic interventions are necessary. Literature suggests that 10% of children at school enrolment have chronic middle ear hearing loss in both ears. This high percentage clearly shows the relevance of (infantile) hearing screening.
In the project "Perception and Localization of Binaural Information in Children (PLOBI2go)" a mobile system is being developed to be able to check the hearing ability of children reliably, in a child-oriented and automated run. In contrast to the previous examination methods for the "U8" and SEU, the aim is not to examine the hearing thresholds, but rather hearing situations/ conditions relevant to everyday life. Thus a statement can be made regarding the maturity of binaural hearing. Binaural hearing, for example, is an important prerequisite for identifying the direction from which a sound comes. Or to be able to follow a conversation in a noisy environment.
Since younger children are not used to wearing clinical audiological headphones, measurements often have to be made with loudspeakers (i.e. in the free field). In addition, measurements with headphones do not represent natural hearing in real environments in an ecologically valid way. The PLOBI2go system will take these aspects into account and will also be designed as a mobile system for changing application locations. Depending on the requirements and size of the available space in the room, the number of loudspeakers can map the front semicircle (±105°) as well as a full circle; in 5-15° intervals (and 45° in the rear area).
In order to test the procedure, a pilot study with 20 young adults with normal hearing was conducted. In the listening experiment, the loudspeakers were positioned in an angular range of ±90°. The localization ability as well as the auditory spatial discrimination by measuring minimum audible angles (MAA) and speech comprehension in noise for a 300 ms signals (pink noise and a speech excerpt /alors/ from the International Speech Test Signal (ISTS)) were tested. In addition, a listening experiment with headphone presentation were conducted with the same conditions and comparable acoustical cues. The results of both listening experiment were compared to verify whether the procedure is also suitable for free field presentation in young children.
Starting in March 2022, children (4.5 years and older) will be measured with the PLOBI2go system. In general, the PLOBI2go system will later be used in kindergartens, health offices, pediatrician practices or also in inclusion counseling or social pediatric centers.

Keywords: Localization, MAA, *binaural hearing, children, mobile system*

480 - Digits in noise test In Brazilian Portuguese: influence of demographic and socioeconomic variables on normal hearing

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There is an exponential growth in mobile technologies that have been transforming different aspects of society, including the healthcare area. This represents an important opportunity for the dissemination of various solutions of this nature. The Digits in Noise (DIN) test is an automated hearing screening test adapted for use on mobile devices. Three-digit strings (0-9) are displayed in the presence of noise. The speech stimulus presentation level is fixed and the masking noise level is adaptively increased or decreased, until the signal/noise ratio is obtained in which the individual was able to correctly recognize 50% of the presented stimuli. This level is called the speech recognition threshold (SRT). The DIN was recently translated and is being adapted to Brazilian Portuguese. Therefore, it is in the process of validation, and it is extremely important to know what its results are in relation to demographic and socioeconomic variables in normal hearing individuals so that they can be exempt from the influence of the type, degree and configuration of hearing loss in people with hearing loss. Objective: To verify the influence of demographic and socioeconomic variables on the digits-in-noise test (DIN) for Brazilian Portuguese in normal hearing. Methods: Cross-sectional and prospective study. The convenience sample consisted of 151 normal hearing subjects aged between 12 and

79 years who underwent basic audiological assessment and digits test in white noise with a sequence of numerical triplet in diotic stimulus (inphase) in the same day. DIN was performed with a Motorola Z3 play smartphone with internet access with in-ear headphones. The digit recognition thresholds in noise (speech recognition threshold - SRT) were analyzed as a function of gender, age, education and socioeconomic level. In order to compare independent samples, non-parametric Kruskal-Wallis and Mann-Whitney tests were used, adopting a significance level of 5%. Results: The mean DIN SRT in the studied sample was -8.47 dB (SD - 3.89), with a median of -9.6 dB. The DIN SRT was more negative the higher the level of education, the higher the socioeconomic level and the younger group. There was no evidence of gender influences on the DIN SRT. Conclusion: There was influence of age, education and socioeconomic level; these variables should be considered when analyzing the performance of the DIN in Brazilian Portuguese in normal hearing subjects.
Keywords: hearing, smartphone, telehealth, adults, elderly; education, socioeconomic level.

494 - Self-care and Audiology literacy
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Introduction**:** The increase in health literacy has promoted self-care. The importance of self-care, combined with easy access to remote consultations in the area of audiology, means that users only go to hospitals when they are advised by professionals in the area. Apps appear on the market more and more, for hearing screening, auditory processing, tinnitus assessment, among others, which allows for greater awareness of hearing problems and their impact on people's quality of life. The responsibility of each citizen to improve their health status through their behavior is today a reality. The notion of self-care monitored using Apps and remote consultations (Tele-audiology) prove to be valuable instruments for a targeted referral and only when necessary.
Objective**:** The aim of this study is to determine the knowledge/use of the young adult population about Apps in the field of Audiology.
Material and Methods**:** After obtaining authorization from the Institute Polytechnic of Coimbra Ethics Committee, a questionnaire was disseminated to polytechnic students aged between 18- and 25-year-old.
Results**:** The answers show some knowledge about the existence of these tools, however still little used. The widespread opinion on the importance of this practice and its use even after the pandemic is highlighted.
Conclusion**:** There was literacy with regard to self-care in Audiology, but still with little recourse to the use of apps.
This work is co-financed by the European Regional Development Fund (ERDF), through the partnership agreement Portugal2020 - Regional Operation Program CENTRO2020, under the project CENTRO-01-0247-FEDER-047083 A4A: Audiology for All.
Keywords: Tele-audiology; Self-care; Apps; Audiology literacy

374 - Virtual platform on tinnitus management: a scientific technical access tool for speech therapists
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Tinnitus is a prevalent symptom in the audiological clinics and the speech therapist participate in the assessment, diagnose and intervention of tinnitus. A range of studies are developed with the aim to promote auditory health; thus, telemedicine is an option for this purpose. According to the purpose of telemedicine, the aim of the present study was to develop and to evaluate a virtual platform on tinnitus management for speech therapists. The purpose was to offer distance learning course, by means of *Portal do Zumbido*, available in the following eletronic address: zumbido.fob.usp.br/. The platform was composed for modules and comprised the introduction to the symptom, assessment and intervention for tinnitus and the elaborated information is presented by means of infographics, available to download. Speech therapists of different regions of Brazil, receveid an e-mail invitation to participate in the study and 46 were registered. From all the 46 speech therapists registered, 38 evaluated the virtual platform, by means of a questionnaire about the theoric content and a Motivational Research. The professionals correctly answered 90% and 100% of the questions, which means the content was learned, in addittion, the content was impressive when the Motivational Research was analysed. The Portal do Zumbido was elaborated and provided in the following eletronic address: zumbido.fob.usp.br/, furthermore, the speech therapists made satisfactory evaluation.
Key words: Telemedicine. Tinnitus. Hearing aids. Learning.

P.12 – FAMILY PERSPECTIVE / EMPOWERMENT

487 - Ears that Hear
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I have authored Ears that Hear as a resource picture book directed at primary aged children. It tells the story of two sisters Ally and Sam. One of the sisters; Sam, is bilaterally deaf and wears hearing aids. The girls discuss the soft sounds and the loud sounds they hear together in their household and community.
The book features an interactive page for students to think about and record what they are hearing in their day. As well as a uniquely illustrated Audiogram highlighting the sounds discussed in the story and at what decibel each of those sounds sit.
This story book is a resource for teachers, families and children as a way to introduce the subject of hearing loss and hearing awareness for both mainstream and specialised pathways.

Additionally, a kind and lovely story for families, early support facilitators, teachers of the deaf and integration aides fostering awareness and inclusion.
It's a straightforward introduction that early primary students can easily understand and draw comparisons too. It offers an appreciation for differences in each other both seen and unseen, in this instance hearing. Giving an opportunity for learning concepts and contributing to the development of emotional intelligence. The beginning of life-long knowledge about hearing awareness and hearing protection.
The poster presentation will display a story board, the blurb, the audiogram as well as a copy of the book.
Keywords*:* hearing loss, family empowerment, family perspectives, education, awareness, inclusion, early intervention.

153 - Beyond the Newborn Hearing Screen: Family perspectives, Empowerment and Well-being
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Well established universal newborn hearing programs categorically exists in many countries. In Melbourne, Australia this service is provided by the Victorian Infant Hearing Screening Program (VIHSP) state-wide throughout maternity and birth units and sees all newborns offered a hearing screen within the first few days of life.
All evidence suggests that hearing screening programs are well received and outside of providing informed consent communication, families opt in to the hearing screening pathway routinely with little to no encouragement. This can be contributed to the enormous amount of intensive promotion that occurred at set up stage. Along with current ante natal education, the number of families declining hearing screens is nominally low. Essentially, the newborn hearing screening (NHS) is a prominent and successful hearing health service.
Can we do more? An adjusted education poster for families and community illustrating hearing issues beyond the NHS? A tool to integrate into antenatal classes (alongside promoting the hearing screening service), as well as Maternal Child Health Nursing training. With an additional objective of extending into kindergarten and child care centre education.
Education for community and professionals is of course available. For the most part though, families have a universal newborn hearing screen in hospital at the birth of a child and unless there is a referral to audiology or significant risk factor, there is no further follow up. There is a quiet assumption that all is well, until a carer or teacher or another medical professional suspects hearing loss or learning delays. Those families diagnosed with hearing loss at birth are educated quickly and explicitly and services are generally provided succinctly. It's the families that may be faced with progressive hearing loss or learning delays down the road and those health providers working with those families that benefit from a more ongoing education plan.
In the demanding role of implementing and fulfilling the operational needs of a hearing screening program, the consistent and relevant educational material expressed to our families and partnerships can become misdirected. Supplementing our educational focus holistically to a more lifelong course could reinforce the existing services available and contribute to additional early hearing loss detection at any stage of the child's life.
Some of the themes that continue to be expressed by families are;

- "My child responds to slamming doors/loud noises so why should I do a hearing screen or an audiology appointment."
- “My baby has passed the hearing screen at birth, so she can hear.
- “I think it would be better to wait until he is older”

In the effort to inform families, teachers and health professionals of the changeable nature of hearing health and hearing loss, the poster will pinpoint why infants (and children) may respond to loud noises. Highlighting that soft sounds of speech and language that are required for learning are far more difficult test without specialised involvement and equipment. As we know, the earlier a baby can hear, the earlier the brain is exposed to language and the earlier they learn that language, with as little "catch up" time as possible.
Likewise, the same reasons exist for identifying hearing loss as early as possible after a passed hearing screen at birth. Emphasising the need for early intervention to successfully reduce language and speech delays, behavioural issues and future literacy concerns, aiming to reduce the gaps between birth and pre-school. Diminishing additional impact on the child's well-being, identity and confidence. Launching an easy to understand reference of milestones for hearing and language, in first 18 months and up to 3-5 years of age. Strengthening the knowledge that passing a hearing screen at birth does not grant competent hearing for a lifespan. The newborn hearing screen is the beginning of the hearing lifecycle.

A straightforward model of the different types of hearing loss with risk factors for hearing loss at various ages, as well as the impact of mild to moderate hearing loss on a child's learning and development, will assist families to understand hearing loss further. Encouraging awareness, the key to empowering our families in the partnership for improved language, health and quality of life. Providing each child the best possible start, at the earliest possible time.
Keywords: Newborn hearing screen, health, family perspectives, empowerment, education.

180 - Hearing loss among childhood cancer survivors: Understanding child and family experiences
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Background**:** The treatment of childhood cancer is one of the remarkable medical success stories of the last few decades. However, as more efficacious therapeutic regimens have dramatically increased survivorship rates, so, too, have unintended consequences increased, including hearing loss, which occurs in up to 90% of young cancer survivors who were treated with platinum-based drugs (e.g., Landier et al., 2014). Platinum-induced hearing loss is typically characterized as permanent, bilateral high-frequency hearing loss. Many children who acquire hearing loss through cancer treatment will need hearing aids, special education, and rehabilitation support to help their language and speech skills develop. In addition, their parents will need support and guidance in establishing a home environment that targets and nurtures meaningful and mutually accessible communication with their child with a newly identified hearing loss.
Aim**:** The aim of this study was to explore how parents of young cancer survivors perceive, experience, and manage their children’s intertwined diagnoses of cancer and hearing loss, with a view to addressing family and child needs for information and support. This study consisted of two parts. The first part – to which the current presentation applies – was to obtain this information from the perspective of audiologists and teachers of the deaf and hard of hearing. Following treatment, the professionals with expertise in hearing loss who are most closely and frequently affiliated with these children and their parents are audiologists and teachers of the deaf and hard of hearing. Thus, these professionals are in a unique position to perceive the experiences and needs of the children and parents. The second part of this study (forthcoming) will obtain this information through parent interviews.
Method**:** An anonymous online survey, consisting of both closed- and open-ended questions, was developed for public health audiologists and teachers of the deaf and hard of hearing in a western Canadian province. Questions focused on professionals’ background and experiences working with at least one child who had acquired hearing loss. In addition, each respondent could provide de-identified information on up to 4 child cases. A total of 18 teachers provided information on 42 cases, and 8 audiologists reported on 26 cases. Descriptive statistics were used to analyze the closed-ended data about professionals and thematic analysis was used to analyze the open-ended child case data.
Findings**:** Both groups of professionals identified the social-emotional impact of living with both cancer and hearing loss as the strongest and most pervasive child need. Teachers also detailed the negative impact of the hearing loss on academics and communication, but emphasized the necessity of addressing social-emotional needs prior to or currently with other needs. Both audiologists and teachers identified social-emotional

challenges and scarce specialized mental health community resources as significant barriers to family adjustment. In addition, both groups described their own needs for a deeper understanding of the long-term implications of the dual diagnosis, including social-emotional, cognitive and medical aspects.
Conclusion**:** From the perspective of the audiologists and teachers of the deaf and hard of hearing in this study, children who acquired hearing loss through treatment for cancer and their families have pervasive needs for social-emotional support; the children also experience unique academic and communication challenges. These professionals identified not only barriers experienced by the children and their families but also suggested possible avenues for support.

367 - Parent child relational reciprocity and social functioning in deaf or hard-of-hearing and typically hearing children

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Introduction The parent-child relationship is likely the first interpersonal relationship children experience that sets the prerequisite for all future relationships. This is an essential social environment for children to learn and observe social cues and process social information. Yet, deaf or hard-of-hearing (DHH) who grow up with hearing parents, may have more difficulties accessing these parent-child interactions compared to their hearing peers. Frustrations and misunderstandings may permeate the relations between parent and child especially post-diagnosis which can subsequently impact children's development of social functioning. Thus, the aim of this study is to examine the differences in the quality of the parent-child relationship (parent-child positive interactions, conflict, dependency) between children with and without hearing loss, and to examine the relation between the quality of the parent-child relationship and children's social functioning.
Method 113 DHH children and 137 typically hearing (TH) children were recruited from a hearing and speech rehabilitation centre in China. All children were aged between 2-8 years (mean = 57.57 months, *SD* = 14.58). Parents completed the Child Parent Relationship Scale (CPRS) and the Strengths and Difficulties Questionnaire (SDQ) for this study. The CPRS consists of three subscales on the quality of parent-child relationship: positive interactions, conflict, and dependency, whilst the SDQ consists of 5 subscales. For this study, the SDQ subscales hyperactivity and problem behaviour were combined to form the index 'externalizing behaviour', and the subscales peer relation and prosocial behaviour were combined to form the index 'social competence'.
Results Parents of DHH children reported fewer positive interactions with their child than parents of TH children, whilst there were similar levels of conflict and dependency recorded for the two groups of children. Further analysis showed that both groups followed the same trend when examining how parent-child positive interactions, conflict, and dependency related to the children's social competence and externalizing behaviour. For all children, more positive interactions with parents related to higher social competence, whereas more conflict and dependency between parents and child related to lower social competence and more externalizing behaviour.
Discussion Parents of DHH children reported fewer positive interactions with their child than parents of TH children. These families may still be in the period of adjustment after diagnosis and treatment and a lot of time was taken up with hospital appointments and early intervention. Therefore, these families with DHH children may still be fine-tuning their strategies for communicating with their child and sustaining their child's attention during interactions, which can lead to less back and forth between them. Importantly, the quality of parent-child relationships was closely related to children's social functioning in both groups to a similar extent. Early intervention programs should take note and strive towards building on the parent-child relationship as early as possible especially with facilitating reciprocal positive interactions.
Keywords*:* deaf, hard-of-hearing, parent child relationship, social competence, externalizing behaviour

141 - Empowerment along the hearing patient journey: the multifaceted role of participation

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The past decades have produced a growing collection of research and interventions focused on patient empowerment in a variety of chronic conditions. However, the intersection of hearing loss and empowerment

from the hearing-aid users' perspective has received little research attention. Zimmerman's oft-cited theoretical empowerment framework suggests that empowerment takes on different forms in different contexts, and therefore a population- or context-specific definition is necessary. This highlights the need for an empirically driven definition of empowerment tailored to the hearing patient journey. We conducted an in-depth semi structured interview study at two research sites: ORCA Europe in Stockholm, Sweden, and National Acoustics Laboratories in Sydney, Australia. 18 adult hearing aid users who recently experienced their first hearing rehabilitation (within the last 6 to 36 months) were included; eight (two females) participants in Sweden and ten (five females) in Australia. Thematic analyses demonstrated that, aligned with Zimmerman's theory of psychological empowerment, knowledge, skills and strategies, participation, self-efficacy, and control were important aspects of the hearing patient journey. Acceptance of hearing challenges/need for hearing aids was extracted as an additional, unique, dimension. Each participant talked about all the empowerment dimensions, with individual variation in which dimensions were most emphasized along their unique hearing patient journey. The empowerment journey for the hearing rehabilitation patient is unique from the patient journey in other chronic illnesses. In general, participants started the process of empowerment prior to meeting a hearing care professional, which indicates that the catalyst for the empowerment process may be initiated before the first clinical meeting. The participation component of empowerment manifested in multifaceted ways, through feelings of lacking participation and actively participating in both their hearing rehabilitation and aspects of social life, including family and informal social relationships. Participants felt comfortable allowing their hearing care professional to drive clinical visits, but they also liked to participate in decision making regarding their hearing care. In addition to shared decision making, participants expressed that they experienced participation through being involved in the adjustments and conversations that make up their visits to their hearing care professional. At times they also felt that they lacked participation in their clinical visits, e.g. participants who felt that their audiologist did not give them space to talk. However, this was not always framed negatively, and instead looked upon as letting the expert hearing care professional do their job. Participation and lack of participation in social life was another robust topic for participants. Many felt isolated and left out upon onset of hearing challenges and shared that being fitted with hearing aids allowed them to be part of their own lives again. Regaining the ability to participate in their life was reported as one of the main sources of satisfaction after getting hearing aids. The findings and insights from this research can be used to finetune person-centered hearing rehabilitation, be applied to future studies exploring the roles of hearing care professionals and communication partners in the empowerment process, and to future quantitative investigations of the empowerment dimensions.

Keywords: Empowerment, hearing patient journey, qualitative, participation

327 - Empowerment from the eyes and ears of audiologists

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Empowerment is a buzzword that is often used in relation to care and management of a variety of chronic conditions. The past decades have produced a growing collection of research and interventions suggesting that patient empowerment leads to better health outcomes in these types of illnesses. Hearing loss can in many cases also be seen as a chronic condition, therefore it is relevant to study it from an empowerment perspective. However, the intersection of empowerment and hearing loss from a audiological care perspective has received little research attention. In an earlier study, we used Zimmerman's (1995) theory of patient empowerment as a framework to conceptualize empowerment on the hearing journey, from the patient perspective. Through thematic analyses of in depth semi-structued interviews, we confirmed that knowledge, skills and strategies, participation, self-efficacy, and control were important aspects of the hearing patient journey. The current study builds on this work. By investigating empowerment from the viewpoint of audiologists, the purpose was to gain insights about how Swedish audiologists relate to empowerment, both how they intersect with the patients' empowerment process and their own feelings of empowerment in their role. This poster presentation reports findings from focus groups with audiologists who work within hearing rehabilitation in Sweden, in both public and private clinics. A topic guide was developed with questions that covered each of the mentioned empowerment dimensions, and a series of individually adapted follow-up prompts. Thematic content analysis was used to explore and examine the data at manifest and interpretive levels. The preliminary analysis displayed in this poster reveals how audiologists perceive the dimensions of empowerment, and think about their role in the empowerment process. Themes discussed are knowledge acqusition and sharing, the importance of participation and what's enabling participation, reflections about the importance of patients developing skills, strategies and/or self-efficacy and the importance of having control over hearing situations.The results are discussed in relation to previous findings on the patient perspective of

empowement within audiology.This research builds onto previous work investigating the experience of being an audiologist, and adds valuable insights regarding how to finetune clinical care within audiology.
Keywords: qualitative, audiologists, focus groups, empowerment

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