Abstract book

Third International Conference on Cognitive Hearing Science for Communication

14–17 June 2015
Linköping, Sweden
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Cognitive Hearing Science
for Communication

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Welcome

It is an honour and a real pleasure for the scientific and organising committees to welcome you to Linköping and the third International Conference on Cognitive Hearing Science for Communication. The conference is an important step in establishing the field of Cognitive Hearing Science worldwide. We are delighted that leading scientists within this emerging field readily accepted our invitation to speak and we are overwhelmed by the quantity and quality of poster submissions. In collaboration with Karolinska Institute we have a pre-conference program which targets presentations by PhDs and young researchers in the field. We are convinced that the conference will be a major success. The field of Cognitive Hearing Science is definitively here to stay. We hope that you will enjoy this event.

Jerker Rönnberg  Maria Hugo-Lindén  Bengt Westerberg
Chair of the Scientific  Chair of the Organizing  Chair of the Swedish Institute
Committee  Committee  for Disability Research

Scientific committee

Jerker Rönnberg, chair
Björn Lyxell, co-chair
Mary Rudner, co-chair

Gerhard Andersson, Stig Arlinger, Ruth Campbell, Berth Danermark, Henrik Danielsson, Louise Hickson, Larry Humes, Ingrid Johnsrude, Birgitta Larsby, Thomas Lunner, Elina Mäki-Torkko, Claes Möller, Brian Moore, Kathy Pichora-Fuller, David Pisoni, Birgitta Sahlén and Stefan Stenfelt.

Organization committee

Maria Hugo-Lindén, Marie-Louise Lund Mattsson and
Britt-Marie Alfredsson-Svensson
Swedish Institute for Disability Research
The Swedish Institute for Disability Research (SIDR) was founded in 2000 in cooperation between the universities of Linköping and Örebro. Since 2012, Jönköping University is formally also a part of SIDR. Disability Research is an interdisciplinary subject and includes medical, technical, behavioural and cultural perspectives. In research and research training SIDR aims to pursue excellence, adopt the perspective of the individual, promote collaboration with user organisations and industry and promote development of the International Classification of Functioning (ICF). The SIDR graduate program is a leading European research program in Disability. Presently, 71 doctoral theses have been successfully defended. For further information about SIDR, please visit www.ihv.se.

Linnaeus Centre HEAD
In 2008, Linköping University received a major 10-year grant from the Swedish Research Council to create Linnaeus Centre HEAD. HEAD stands for HEaring And Deafness and thus indicates the field of research. Linnaeus Centre HEAD forms part of the Swedish Institute for Disability Research. The backbone of the centre is a multidisciplinary research team, comprising a core group of senior scientists, postdoctoral research fellows and national and international collaborators. For further information about Linnaeus Centre HEAD, please visit www.headcentre.se.

HEAD Graduate School
HEAD Graduate School is run in collaboration between the universities of Linköping and Örebro within the framework of the Swedish Institute for Disability Research. It is also affiliated with Linnaeus Centre HEAD. The graduate school promotes excellent research training and is open to doctoral students whose projects fall within the broad field of hearing and deafness research. The activities of the graduate school include courses, seminars, workshops and mobility incentives and it provides an excellent forum for developing links between research, clinicians, user organisations and industry. At present, 30 doctoral students are enrolled at the graduate school and a further 21 have already obtained their PhDs and 1 Licentiate. For further information about HEAD Graduate School and its activities, please visit www.ihv.se/head.
Excellence in Cognitive Hearing Science

HEAD stands for HEaring And Deafness this is the research focus of Linnaeus Centre HEAD and HEAD Graduate School. Working for excellence in Cognitive Hearing Science.
Pre-conference programme

**Sunday, June 14**

09.00 – 16.00 Registration (Marmorfoajén) and pre-conference, Linköping Konsert & Kongress.

09.00 – 09.30 Technical/practical information for pre-conference speakers (Crusellhallen).

09.55 – 10.00 Welcome to CHSCOM2015 pre-conference: *Mary Rudner* and *Anna Magnusson* (Crusellhallen).

10.00 – 12.00 Pre-conference session 1.
   Moderators: Carine Signoret and Håkan Hua

10.00 – 10.20 A qualitative shift in comprehension strategies revealed under the triple challenge of age, reduced hearing acuity, and complex linguistic input. *Nicole Amichetti*

10.20 – 10.40 Assessing the influence of auditory attention on sentence recognition using neural entrainment. *Jana Müller*

10.40 – 11.00 The effect of listening on balance control. *Mohammed Alshamrani*

11.00 – 11.20 COFFEE BREAK (Marmorfoajén)

11.20 – 11.40 Multi-task training of auditory amplitude modulation: When learning two things at once can help or hinder. *David Maidment*

11.40 – 12.00 Do older listeners adjust the parameters of word recognition when speech signal reliability decreases? *Laurence Bruggeman*

12.00 – 13.00 LUNCH (Garden)

13.00 – 16.00 Pre-conference session 2.
   Moderators: Elaine Ng and Traci Flynn

13.00 – 13.20 Greater reliance on magnitude manipulation during mental arithmetic in deaf signers compared to hearing non-signers: fMRI evidence. *Josefine Andin*

13.20 – 13.40 Sign language phonological awareness supports word reading in deaf beginning readers. *Emil Holmer*

13.40 – 14.00 Hearing Faces: Lip reading and face processing in cochlear implant users. *Maren Strophal*
14.00 – 14.20  COFFEE BREAK (Marmorfoajén)

14.20 – 14.40  Staggered development of the auditory brainstem neurons involved in processing of temporal sound cues in deaf mice.  
Sara Leijon

14.40 – 15.00  The Test of Attention in Listening (TAiL):  
An event-related potential study.  Hannah Stewart

15.00 – 16.00  COFFEE BREAK (Marmorfoajén)

Conference programme

Sunday, June 14

09.00 – 16.00  Registration (Marmorfoajén) and pre-conference, Linköping Konsert & Kongress.

16.00 – 16.05  Welcome to CHSCOM2015: Bengt Westerberg, Main moderator and chair of the Swedish Institute for Disability Research (Crusellhallen).

16.05 – 16.20  Welcome to Linköping: Folke Sjöberg, Deputy Vice-Chancellor of Linköping University.

16.20 – 16.25  General information CHSCOM2015: Bengt Westerberg, Main moderator.

16.25 – 16.35  Introduction to Cognitive Hearing Science: Jerker Rönnberg, Chair of the scientific committee and director of Linnaeus Centre HEAD.

16.35 – 17.05  Keynote: Bencie Woll. Multimodality in language.

17.05 – 17.35  Keynote: Arthur Wingfield. Age, hearing, and cascading effects for perceptual effort.

18.00 –  RECEPTION (Marmorfoaljén)

Monday, June 15

07.30 – 08.30  Technical/practical information for speakers (Crusellhallen)

08.30 – 08.35  Welcome and general information: Bengt Westerberg, Main moderator (Crusellhallen)

Session moderator: Mary Rudner
08.35 – 09.00 Keynote: **Sandra Gordon Salant.** Disentangling effects of age, hearing, and cognition on distorted, distracting, and demanding speech understanding tasks.

09.00 – 09.20 Some factors underlying speech-identification performance in multi-talker competition. **Larry E. Humes**

09.20 – 09.40 Task-evoked arousal during speech recognition in noise by older adults with hearing loss. **Stefanie E. Kuchinsky**

09.40 – 10.00 Musical training and the aging brain. **Claude Alain**

10.00 – 10.30 **COFFEE BREAK (Marmorfoajén)**

10.30 – 10.50 Vocal emotion affects speech understanding and recall in noise. **M. Kathleen Pichora-Fuller**

10.50 – 11.10 Hearing loss and episodic long-term memory. **Jerker Rönnberg**

11.10 – 11.30 **BREAK**

Session moderator: **Jerker Rönnberg**

11.30 – 11.55 Keynote: **Nina Kraus.** Auditory-motor rhythmic skills and neural synchrony: A framework for auditory processing

11.55 – 12.15 Auditory processing in noise: A preschool biomarker for language development. **Travis White-Schwoch**

12.15 – 13.15 **LUNCH (Garden)**

13.15 – 13.35 Central/cognitive load modulates peripheral/perceptual processing. **Patrik Sörqvist**

13.35 – 13.55 The effect of attention on the pupil dilation response while listening to speech in noise. **Thomas Koelewijn**


14.15– 17.00 Poster session for even poster numbers (Marmorfoajén)

17.30 – **SOCIAL ACTIVITY – SWEDISH MIDSUMMER BUFFET**

(Marmorfoajén)
**Tuesday, June 16**

07.30 – 08.30 Technical/practical information for speakers (Crusellhallen)

08.30 – 08.35 Welcome and general information: Bengt Westerberg, Main moderator (Crusellhallen)

  Session moderator: Björn Lyxell

08.35 – 09.00 Keynote: Steve Majerus. Interactions between verbal short-term memory and speech perception in suboptimal hearing conditions.

09.00 – 09.20 Extrinsic cognitive load disrupts low-level speech perception.

  Sven Mattys

09.20 – 09.40 Anticipation of what’s coming up next: working memory and processing speed mediate predictive language processing.

  Esther Janse

09.40 – 10.00 Predictive coding and the perception of degraded speech.

  Matt Davis

10.00 – 10.30 COFFEE BREAK (Marmorfoajén)

10.30 – 10.50 Predicting speech-in-noise perception using the trail making task: Results from a large-scale internet study.

  Rachel Ellis

10.50 – 11.10 Cognitive factors in the comprehension of dynamic conversations.

  Gitte Keidser

  Session moderator: Thomas Lunner


11.35 – 11.55 How the brain discovers patterns in sound sequences.

  Maria Chait

11.55 – 13.00 LUNCH (Garden)

13.00 – 13.20 Neural oscillations in ageing and hearing-impaired listeners.

  Malte Wöstmann


  Tobias Overath

14.00 – 14.20 Changes in alpha oscillations in normal hearing adults and in adult cochlear implant users during a speech-in-noise task. 
Catherine M McMahon

14.20 – 17.00 Poster session for odd poster numbers (Marmorfoajén)

18.30 – 19.00 Refreshments (Garden)

19.00 CONFERENCE DINNER – ENTERTAINMENT (Garden)

**Wednesday, June 17**

07.30 – 08.30 Technical/practical information for speakers (Crusellhallen).

08.30 – 08.35 Welcome and general information: Bengt Westerberg, Main moderator (Crusellhallen).

Session moderator: Claes Möller

08.35 – 09.00 Listening, is it all in your head? Cognitive training for adult hearing aid users. Helen Henshaw

09.00 – 09.20 Individual differences and audiovisual information processing in perceptual adaptation to distorted speech signals. Patti Adank

09.20 – 09.50 COFFEE BREAK (Marmorfoajén)


10.15 – 10.35 Cross modal plasticity in children with cochlear implants: An event related potential study. David P. Corina

10.35 – 11.00 BREAK

11.00 – 11.20 Visual motion processing in deaf adults and children. Rain G. Bosworth

11.20 – 11.40 A working memory role for superior temporal cortex in deaf individuals independently of linguistic content. Velia Cardin

11.40 – 12.00 Working memory for manual gestures is influenced more by poor visual resolution when working memory load is high. Mary Rudner

12.00 – 12.10 Thanks and summary: Bengt Westerberg and Jerker Rönnberg

12.10 LUNCH-TO-GO (Marmorfoajén)
1 Main entrance
2 Marmorfoajén
3 Crusellhallen
4 Backstage
5 Garden
6 Entrance
Linköping University is renowned as an innovator in education and research. It was the first in Sweden to introduce several different educational programmes, interdisciplinary theme-based research, research schools and problem-based learning.
Abstracts

Pre-conference
A Qualitative Shift in Comprehension Strategies
Revealed Under the Triple Challenge of Age,
Reduced Hearing Acuity, and Complex Linguistic Input

Nicole M. Amichetti¹ and Arthur Wingfield¹

¹Volen National Center for Complex Systems, Brandeis University, USA

Although it has been assumed in classic psycholinguistic theory that sentence comprehension is accomplished through a detailed syntactic analysis of an utterance, recent evidence suggests that sentences may be processed in a more superficial heuristic manner, in which meaning is rapidly extracted from a few key words combined with semantic plausibility. In two experiments we examine whether either approach – a full syntactic analysis or a rapid heuristic approach - becomes more prevalent with increasing age and with increasing perceptual effort due to reduced hearing acuity. We further examine whether this change is based on comprehension demands. Participants listened to grammatical sentences that contained either implausible or plausible semantic relations and were asked to identify the thematic roles. In Experiment 1 participants were young and older adults with good hearing acuity. We show that plausibility overrides a full syntactic analysis in cases where sentence constructions are complex (active versus passive constructions) and that this effect is differentially larger for older adults relative to younger adults. In experiment 2, we contrasted older adults with good hearing acuity versus older adults with mild-to moderate hearing loss. Young adults with good hearing were also tested. We increased the level of syntactic complexity by contrasting sentences with subject-relative versus more complex object-relative clause structures. We show that when processing demands are increased by the syntactic complexity of the speech materials, and under the challenges of increasing age and declining hearing acuity, there is a greater shift from a detailed syntactic analysis to a plausibility-based heuristic.
Assessing the influence of auditory attention on sentence recognition using neural entrainment

Jana Müller¹
Birger Kollmeier¹,², Stefan Debener¹ and Thomas Brand¹

¹Cluster of Excellence “Hearing4all”, University of Oldenburg, Germany
²Department of Medical Physics and Acoustics, University of Oldenburg, Germany

The human ability to suppress interfering noise and to focus on relevant sounds in an auditory scene is essential for speech understanding in noisy environments. However, speech-reception-thresholds (SRTs) show large inter-individual and intra-individual differences particularly in noisy listening conditions. In this study we investigate the role of auditory attention or rather the state of attention on the variability of speech reception based on neural entrainment. Sentences of the Oldenburg sentence test were presented in 7 Hz sinusoidally modulated noise. Moreover, 0, 1, or 2 peaks of the noise masker were reduced in amplitude, so called decrements. The participants’ task was either to count the decrements in the noise masker or to repeat the sentence as accurate as possible. In this way the participants’ attention was drawn either on the peaks of the noise masker or on the speech in the gaps. These tasks were either performed in single task (ST) or in a dual task (DT, both tasks at the same time) while high density EEG was recorded.

First pilot results confirm our hypothesis based on the “Entrainment Hypothesis” (Schroeder & Lakatos, Trend in Neuroscience; 2009), that in trials where attention was on the noise masker (steady state signal) an increase in EEG power and an increase in phase consistency at the modulation frequency are observable. Furthermore, differences in the state of attention were found by separating trials in groups of correct and incorrect repeated trials and by analyzing the EEG data with respect to spectral energy and phase information.
Regulating balance is a complicated process controlled by the brain. In order to maintain balance efficiently, information from the somatosensory, the visual and the vestibular systems is integrated. Recently other influences on balance control have been reported, namely: attention (Deviterne et al, 2005) and sound (Al’tman et al, 2005). Balance control is seemingly an automatic and effortless task, however, several studies indicate that balance control requires attention and that there can be interactions between maintaining balance and performing other cognitive tasks (Woollacott & Shumway-Cook, 2002) as they share common cognitive resources (Fraizer & Mitra, 2008).

The aim of this study is to investigate the effects of an auditory task on balance control using a dual-task paradigm. 33 normal participants (21 males and 12 females) aged 19-61 (mean age 39.7) were asked to complete two balance tasks (normal and Romberg stance with eyes open and closed) with and without a concurrent auditory task (competing words). Balance performance was studied using a Kistler force plate and the center of pressure (COP) in the anterior-posterior and the medio-lateral axis were computed. General sway measures and other analysis variables like mean velocity and planar deviation were calculated. Data revealed increased body sway for both balance tasks whilst completing a concurrent auditory task compared to their baselines. The deterioration in the balance control performance whilst dual tasking may be justified as both tasks are competing for cognitive resources. Further work will resolve how individuals with hearing impairment perform and whether hearing impairment influences balance control.
Multi-task training of auditory amplitude modulation: When learning two things at once can help or hinder

David W. Maidment
Hi Jee Kang, Emma C. Gill, Huw M. Swanborough and Sygal Amitay

MRC institute of Hearing Research, Nottingham, UK

Understanding how tasks interact during multi-task perceptual training has important implications for the optimal design and delivery of applied training programs that aim to improve perceptual abilities. The current study systematically investigated the extent to which random (trial-by-trial), interleaved (in 60-trial blocks) and consecutive (360-trial blocks) training regimens disrupted learning of a primary, auditory amplitude modulation depth discrimination task (AMD) when training was mixed with either the same AMD task with different task-relevant or -irrelevant stimulus features, or an amplitude modulation rate discrimination task (AMR) with the same task-relevant and -irrelevant stimulus features. We found that varying the task-relevant or -irrelevant stimulus features failed to disrupt learning when tasks were interleaved, but was disruptive when tasks were mixed consecutively. Mixing two tasks requiring a different perceptual judgment but sharing the same stimulus features was disruptive for all types of mixed-training regimen (random, interleaved, and consecutive). We propose that disruption always occurs when two tasks are mixed if they require perceptual judgments based on different cues, whereas learning is only disrupted when the same task with different stimulus features are mixed consecutively. The current study therefore provides a novel insight into the underlying mechanisms of amplitude modulation learning. This may have practical implications for intervention strategies directed at hearing-impaired listeners that rely on amplitude modulation cues (e.g. cochlear implant users) in order to improve speech intelligibility in noise.
Do older listeners adjust the parameters of word recognition when speech signal reliability decreases?

Laurence Bruggeman¹
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²Centre for Language Studies, Radboud University Nijmegen, the Netherlands
³Donders institute for Brain, Cognition, and Behaviour, Radboud University Nijmegen, the Netherlands

When young adults listen to reduced, casually articulated speech or speech interrupted by bursts of noise, they flexibly adjust the parameters of word recognition to allow for speech signal unreliability. Normally, onset competitors (e.g., cloud-clown) always compete more for recognition than rhyme competitors (e.g., cent-tent). Under adverse listening conditions, however, young adult listeners treat mismatch more leniently, such that lexical candidates are not immediately deactivated. Consequently, onset competitors compete less strongly, and rhyme competitors compete more strongly than in noise-free conditions. This adjusts for the unreliability of the speech signal. Using eyetracking, we assessed whether this modulation of recognition dynamics also occurs for older listeners. Dutch participants (aged 60+), not wearing hearing aids, with hearing acuity varying from normal-hearing to mild-to-moderate hearing loss, heard Dutch sentences containing a critical word while viewing displays of four line drawings. The name of one picture was a phonological competitor for the critical word, sharing either its onset or its rhyme. The other three pictures were unrelated distractors. Sentences were either clear and noise-free, or had several phonemes in the context of the critical word replaced by bursts of noise. Contrary to earlier results with young adults (showing decreased onset competition and increased rhyme competition due to noise), a larger preference for onset competitors than for rhyme competitors was observed in both clear and noise conditions; performance did not alter across condition. This suggests dynamic adjustment of spoken-word recognition parameters in response to a change in listening condition is less available to older listeners.
Multimodal speech perception on cochlear implanted deaf adults exposed to Cued Speech

Clémence Bayard\textsuperscript{1,2}
Colin Cécile\textsuperscript{2}, Jean-Luc Schwartz\textsuperscript{1} and Jacqueline Leybaert\textsuperscript{2}

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In Cued Speech (CS), a manual system developed to help deaf individuals to understand speech visually, each syllable is uttered with a complementary gesture (manual cue). Nowadays, congenitally deaf children are fitted with cochlear implants (CI). Among them, some use CS and have to combine auditory, labial and manual information to perceive speech. This study examines how audio-visual (AV) integration, involved in AV speech, is affected by manual cues and on which form of information (auditory, labial or manual) the CS receptors primarily rely depending on lip-reading ambiguity. To address this issue, we designed an identification task of two AV McGurk stimuli presented with or without manual cues: a plosive McGurk stimulus (audio /pa/ + lip-reading /ka/) and a fricative McGurk stimulus (audio /fa/ + salient lip-reading /ʃa/). The manual cues were congruent with either auditory information, lip information or the expected fusion. Participants were asked to repeat the perceived syllable aloud. Their responses were classified into four categories: audio, lip-reading, fusion and other. Data were collected from deaf individuals who were experts in CS (N=36), or completely naïve towards CS (N = 35). Individuals of CS group were split depending on their auditory abilities (AO+ vs AO-). Results revealed that deaf individuals merge auditory and lip-reading information into a single unified percept. Without manual cues, participants gave a high proportion of fusion response (particularly with ambiguous plosive McGurk stimuli). Results also suggested that manual cues modify the AV integration and their impact differs between plosive and fricative McGurk stimuli.
Sign language phonological awareness supports word reading in deaf beginning readers

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Spoken language phonological awareness (PA) supports word reading development in hearing children; however, deaf children, who have non-functional levels of hearing and a signed language as their first language, seem to utilize their first language skills to learn to read. We developed a new phonological decision task that can be used to assess PA in both spoken and signed languages, and investigated how these skills were related to word reading in deaf beginning readers (Study 1). We also investigated the validity of our new task in hearing beginning readers (Study 2). Thirteen deaf beginning readers with a mean age of 10 years (SD=2.3) participated in Study 1; in Study 2, 36 normal hearing children with a mean age of 7.5 years (SD=0.3) took part. Groups were well matched on word reading, non-verbal intelligence, and gender distribution. The deaf children performed the new phonological decision task both as a sign similarity task and as a rhyme task; hearing children only performed a rhyme task. Participants also performed motor speed, cognitive speed, working memory, word decoding and lexical decision tasks; in addition, hearing children completed an established test of PA. Correlational analyses across studies indicated that the new task is a valid measure of PA, and that first language PA supports word reading, even when surface forms of first and reading language are completely different. Sign language PA may support word-to-sign mapping or some aspect of orthographic analysis; however, future studies should investigate what the exact function of this skill is.
Cochlear implants (CI) can partially restore hearing in post-lingually deafened individuals. There is evidence that the auditory cortex takes over visual functions during a period of auditory sensory deprivation. It is still unclear if the residual pattern of visual take-over has adaptive or maladaptive impact on the CI outcome. The aim of the present study was therefore to obtain more information about visual processing in CI users. Specifically we investigated whether the distributed sources of face processing are different in CI users compared to normal hearing (NH) individuals. High-density electroencephalogram data were recorded from N=21 experienced CI users and N=21 age-matched controls (aged 20 to 74 years) performing a face versus house discrimination task. Lip-reading and face recognition abilities, as well as speech intelligibility were assessed. Evaluation of ERP topographies revealed significant group differences over occipito-temporal scalp regions. Furthermore, the analysis of distributed sources (using Brainstorm) discovered significantly higher activation in the auditory region of interest (ROI) for CI users, indicating a pattern of visual take-over. Lip reading skills were significantly enhanced in the CI group and appeared to be particularly better after a longer duration of deafness. Face recognition was not significantly different between groups. However, the activation in the auditory ROI of the CI users was positively related to the face recognition ability. To further investigate differences in the neural network of CI users, especially in their audio-visual integration, pilot data on recently developed high quality audio-visual material will be presented.
Deafness profoundly impairs human communication. In children, hearing is essential to their neurocognitive and psychosocial development, least not for the acquisition of speech and language. It is well known that auditory deprivation in early life results in significant limitations in processing of spectral and temporal sound cues in adults, unless the central auditory pathways are stimulated during their developmental period, so called ‘sensitive period’. Today the leading therapy for restoring hearing, the cochlear implant, builds upon electrical stimulation mimicking the temporal sound-pattern. Children that become fitted with a CI in their first years of deafness have good chances of acquiring spoken language, whereas children who receive a CI later in life get progressively less aid from the prosthesis. Thus, it is important to learn how the auditory brainstem, the first site of central acoustic processing, develops in deaf individuals. Here, we use an animal experimental approach to investigate early development of brainstem neurons specifically involved in the processing of temporal sound cues. Congenitally deaf mice lacking cochlear-driven activity in the auditory nerve were compared to age-matched wild-type mice as controls. Electrophysiological characterization of the neurons revealed significant differences between neurons in deaf mice compared to wild-type controls in their intrinsic membrane properties giving rise to spiking activity. Two compensatory mechanisms act in tandem to gradually rescue the ability of these neurons to respond correctly to stimulation. Whether these homeostatic compensatory effects are driven by input-specific activity or if they are instructed by an intrinsic molecular-genetic machinery is currently under investigation.
The Test of Attention in Listening (TAiL): An Event-Related Potential Study

Hannah J Stewart¹²
Sygal Amitay² and Claude Alain¹³

¹Rotman Research Institute, Baycrest, Canada
²MRC institute of Hearing Research, Nottingham, UK
³Department of Psychology, University of Toronto, Canada

The Test of Attention in Listening (TAiL) is a behavioural test designed to assess auditory selective attention in clinical populations using non-verbal stimuli. In a block of trials, participants indicate whether two tones, presented sequentially, have the same frequency or location depending on the task’s instruction. A key part of TAiL’s methodology is that the stimuli do not change throughout the task; just the instructions to the individual do – to pay attention to either the frequency or the location of the tones. Through different combinations of task-relevant and -irrelevant stimulus features, the test provides sensitive measures of distraction and conflict resolution.

This study aimed to explore the underlying neurological networks involved in TAiL’s different measures, using electroencephalography (EEG). Data was collected from 16 individuals aged 18-30. For the distraction measure, a positive component peaking at ~250ms post the onset of the second tone was found – a distraction positivity. Source analysis of this component suggest different sources for the two TAiL tasks (attending to frequency and location), with distraction by location more posterior than distraction by frequency, providing support for the dual-pathway theory. For the conflict resolution measure, a negative frontocentral component (300-450ms) was found reflecting auditory and visual conflict resolution tasks (e.g. the Stroop task). These results reveal distinct neural correlates for distraction and conflict resolution measures. The timing and distribution suggest a progression from sensory encoding to stimulus-response mapping providing further support for the use of TAiL as a selective auditory attention task for clinical populations.
Abstracts

Sunday
Human language is essentially multi-modal, with strong evidence of audio-visual integration during language processing. Spoken language evolved in face-to-face communication, using accompanying gesture (facial and manual); sign language also makes use of a variety of communication channels. There is increasing evidence that multi-modality supports not only communication with others but also cognition in the speaker/signer.

In children born deaf, there is disruption to communicative interaction, including atypical behaviours by caregivers which reduce quantity and quality of input. In addition, the sensory deprivation affects two neurodevelopmental cortical processes: those determining neural structures and connections within primary sensory areas (hearing), and those reflecting compensatory processing in other regions (language). Both are likely to be time-sensitive, although with different sensitive periods.

Following an hypothesis which suggests that visual language may disrupt auditory cortical development during the sensitive period. “..studies of deaf children have demonstrated that (when) CI is less effective .. (it) appears to be related at least in part to communication through sign language, because of cortical reorganization of the auditory cortex.” (p 20., Charroó-Ruíz et al., 2013), some intervention programmes for young deaf children recommend minimising exposure to signs, gestures and speech-reading, because of assumed deleterious effects on the development of auditory cortical circuits following CI.

This presentation reviews current research, demonstrating that in prelingual deafness there is no good evidence that dystrophic processes within A1 are amplified by exposure to visual stimuli, including sign language. As for neuroplastic processes, it will be argued that since A2 is intrinsically multimodal, posterior superior temporal regions are not only critical for the integration of heard and seen speech, but are highly and dynamically responsive to language, regardless of modality. The implications for advice to parents and the design of interventions will be discussed.
Adult aging reflects a balance of declines and compensation. In the domain of language comprehension this balance is represented by age-related declines in hearing acuity and cognitive fundamentals such as working memory, executive function, and speed of processing, rescued to a large degree by spared linguistic knowledge. This balance begins to tip when degraded speech input confronts limited resources and sentences with computationally complex syntactic structures. Since the seminal studies by Rabbitt (1968, 1991) there has been an increasing awareness that successful perception of speech degraded by noise or hearing loss can draw cognitive resources that might otherwise be available for encoding what has been heard in memory, or for the comprehension of rapid, informationally complex speech of the sort one often encounters in everyday life. The goal of this presentation is to characterize the cascading effects of perceptual effort on young and older adults’ speech comprehension and its interaction with age-related hearing loss and the syntactic and suprasegmental features of the speech input. These data will be discussed in the context of the link between hearing loss and cognitive performance, particularly when listeners are faced with the task of understanding speech that is acoustically or linguistically challenging.
Abstracts

Monday
Disentangling effects of age, hearing, and cognition on distorted, distracting, and demanding speech understanding tasks

Sandra Gordon-Salant¹
Grace H. Yeni-Komshian¹, Peter J. Fitzgibbons¹, Julie I. Cohen²,
Juliette Gassert¹, Jaclyn Schurman¹, Douglas S. Brungart²

¹Department of Hearing and Speech Sciences, University of Maryland, USA
²National Military Audiology and Speech Pathology Center,
Walter Reed National Military Medical Center, USA

While the difficulties experienced by older listeners with age-related hearing loss in perceiving speech in noise are relatively well understood, there are many other complex listening situations that potentially have a significant impact on performance by older adults. This presentation will discuss the differential effects of aging and hearing loss for three types of daily communication challenges: perception of accented speech, perception of speech in the presence of distracting visual information, and perception of speech during an auditory task that taxes memory. In some of the experiments, the effects of hearing loss but not age predominate, whereas in others, aging alone is related to significant decline in performance. Findings will be considered in the context of the interaction between bottom-up and top-down processing limitations, as well as abilities that appear to be preserved with aging.
Some Factors Underlying Speech-Identification Performance in Multi-Talker Competition

Larry E. Humes
Gary R. Kidd

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The Coordinate Response Measure [CRM; Bolia et al. (2000) J. Acoust. Soc. Am. 107, 1065–1066] is, perhaps, the most widely used contemporary measure of speech-identification performance in competing-speech backgrounds in the U.S. This corpus of sentences makes use of a highly constrained syntactic structure with sentences having the following format: Ready <call sign> go to <color> <number> now. There are 8 possible call signs, 4 possible colors, and 8 possible numbers for a total of 256 possible sentences. All 256 sentences are spoken by 8 talkers, 4 male and 4 female. In typical administration, the call sign serves as a lexical marker for the target sentence and the color-number pair in this sentence is the target information to be identified by the listener. The same talker, or other talkers, with other call signs and color-number pairs, represent possible competing-speech backgrounds. In a series of experiments with the CRM, we have systematically examined the influence of various factors on performance, including the number of competing talkers (2, 4 or 6), the number of competing messages or sentences, and asynchrony (primarily, 0- or 50-ms onset asynchrony) of the competing messages with the target message. All stimuli were presented monaurally using insert earphones. Results from groups of young normal-hearing listeners will be presented to illustrate the impact of each of these factors on performance. Corresponding data from a group of older adults with impaired hearing listening to spectrally shaped speech will also be presented.
Task-evoked arousal during speech recognition in noise by older adults with hearing loss

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Sudden or unexpected changes in the demands of a task, such as the onset of background noise, can be experienced as highly salient events. In functional imaging studies of speech recognition by younger and older adults, such transitions have been shown to elicit increased brain activity in sensory-specific and domain-general attention regions. However, individual differences in the sensitivity to sudden changes in task demands have not yet been explored. In the current study, we examined the extent to which individual differences in cognitive arousal, as measured with task-evoked pupil dilation, are predictive of the neural response to salient transitions during word recognition in noise for a group of older adults with hearing loss. The results are interpreted in the context of the neural and cognitive systems that optimize word recognition in challenging listening conditions.
As we grow older, we often experience difficulty understanding what a person is saying in the presence of other sounds (e.g., television, music, other people talking). Such age-related declines in listening are a major challenge for hearing science and medicine because of their wide prevalence. Furthermore, hearing aid technologies have so far been unable to effectively alleviate this problem. Here, I will present studies that have investigated the role of musical training as a mean to mitigate age-related decline in difficulties understanding speech in noise. Behavioral and neuroimaging studies provide converging evidence that musicians exhibit exceptional auditory skills that allow them to cope with age-related hearing loss better than non-musicians. In particular, continuous engagement in musical activities throughout adulthood is associated with slower age-related decline in understanding speech in noise. Neuroscience research has shown that musical training enhances central auditory processing, which can compensate for peripheral hearing loss. The benefit of musical training on the aging auditory brain is exciting and it opens new avenues for developing new remediation programs and improving current rehabilitation protocols aimed at helping older adults in noisy environments.
Vocal emotion affects speech understanding and recall in noise

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Emotional content enhances memory for photographs and text, with older adults often performing better with positive emotional stimuli. Word recognition in noise is enhanced when speech is spoken with vocal emotions that capture attention (fear or pleasant surprise). Study 1 investigated the effect of vocal emotion on word recognition and recall younger (n=24) and older (n=24) adults with good audiograms. Two 100-sentences lists divided into recall sets of increasing size were presented in quiet. One list (Original) was spoken in a neutral voice; the other list (Emotional) was spoken in four vocal emotions (fear, sadness, neutral, pleasant surprise). Word recognition accuracy was tested after each item and recall after each recall set. Word recognition accuracy and recall were equivalent for the two age groups in the Original condition, but better for younger than older adults in the Emotional condition. The effect of vocal emotion on word recognition was replicated, with the highest accuracy for stimuli spoken to portray fear. Typical set size effects on recall were found, but recall did not differ across emotions. For younger, but not older adults, recall was better for stimuli spoken in an emotional versus a neutral voice. In followup studies in noise, there were emotion-specific effects on both word recognition and recall.
Hearing loss and episodic long-term memory

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The UK Biobank offers cross-sectional epidemiological data collected on >500,000 individuals in the UK between 40 and 70 years of age. Using the UK Biobank data, the aim of this study was to investigate the effects of functional hearing loss and hearing aid usage on visuospatial memory function. A sub-sample of 138,098 participants was selected. A digit triplets functional hearing test was used to divide the participants into three groups: poor, insufficient and normal hearers. We found negative relationships between functional hearing loss and both visuospatial working memory (i.e., a card pair matching task) and visuospatial, episodic long-term memory (i.e., a prospective memory task), with the strongest association for episodic long-term memory (Rönnberg et al., 2014). The selectivity in effect on memory systems replicate previous results (Rönnberg et al., 2011). In addition, the collective results suggest that the selectivity is independent of encoding format in the memory task (auditory, motor or visuospatial), implying an effect of hearing loss on a multimodal episodic long-term memory system.
Speech contains acoustic information delivered simultaneously across multiple timescales – from sentences that unfold over seconds to phonemic cues that change within milliseconds. The nervous system is tuned into this auditory timing information, with synchronous neural firing across these timescales. We access neurophysiological mechanisms underlying speech processing at fast and slow timescales, with concurrent tests of rhythmic and language skills. It would appear that common neural mechanisms underlie language and auditory-motor rhythmic skills. For example, preschoolers who can entrain their motor output to a syllable-rate beat have superior prereading skills and neural processing of syllabic information. Older children who exhibit more flexibility in adjusting their motor output on the order of milliseconds have superior neural coding at a sub-millisecond level, a neural mechanism that also supports auditory processing for language. Neural activity at slower timescales, on the other hand, underlies the ability to remember and reproduce rhythms occurring at slower, sentence-like rates. These results have led to a new conceptual framework for understanding auditory processing, wherein distributed, but integrated, neural processing at fast and slow rates provides simultaneous sensitivity to crucial linguistic cues across timescales. Successful auditory processing may depend on the integration of neural coding across multiple timescales. Importantly, these neural mechanisms and their behavioral manifestations may be remediated through auditory training. This framework can help us understand how the auditory-cognitive skills underlying everyday communication may be improved.
Auditory processing in noise: A preschool biomarker for language development

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Early childhood is a critical period of auditory learning, when children are mapping sounds in the environment to meaning. Although this mapping bootstraps language development, these experiences rarely occur in ideal listening scenarios; instead, children are exposed to sounds against a constant din. In a longitudinal study of child language development and auditory processing, we have investigated the neurophysiological processing of speech in noise in preschoolers (ages 3-5) and its impact on language milestones. We have found that the neural precision of encoding speech in noise is highly predictive of multiple early literacy skills, including phonological processing and rapid automatized naming. Moreover, this neural precision predicts future language skills longitudinally, and in older children tracks systematically with language skills across a continuum from advanced to impaired, and predicts formal diagnosis of a learning disability. Parallel work in an animal model has elucidated the biological mechanisms underlying these phenomena. Taken together, the neural encoding of speech in noise would seem to be fundamental to language and cognitive hearing development, and these results point to the importance of an integrated auditory-cognitive system in driving language development. Children with relatively poor neural processing may be at risk for neurodevelopmental disorders of language and auditory processing, with a particular bottleneck encoding speech in adverse listening conditions. Pragmatically, evaluating neural processing in noise offers a biological looking glass into a child’s future auditory development, opening up possibilities of early identification of, and intervention for, children at risk for learning problems.
A long lasting debate in selective attention research revolves around the issue of whether irrelevant information is filtered at an early/perceptual processing stage or at a late/cognitive processing stage. Another long lasting debate concerns whether selective attention depends on a single, multi-purpose processing resource or whether it depends on several, independent processing resources. As a reaction to both debates, we have proposed a unified view of attention (Sörqvist, Stenfelt, & Rönnberg, 2012) whereby central/cognitive load modulates peripheral/perceptual processing. Moreover, the unified view of attention embodies a domain-general processing resource – called working memory capacity – that determines people’s capability for attentional/cognitive engagement. Here, we will present data from a recent experiment designed to critically examine this model. Participants undertook a visual-verbal version of the n-back task in various task-difficulty conditions. Cortical processing of a background sound was measured with an fMRI protocol and individual differences in working memory capacity were measured with a package of three complex-span tasks. Our hypothesis is that higher task difficulty (in the n-back task) will be associated with increased prefrontal cortical activity and decreased auditory-temporal activity. Moreover, the magnitude of this effect should be related to individual differences in working memory capacity.
The effect of attention on the pupil dilation response while listening to speech in noise

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A group conversation can be more effortful than talking one-to-one. Research shows that focusing on one talker instead of two and knowing where, when, and who is going to talk improves speech intelligibility. How this affects processing load is unknown. Recently we showed how attentional load affects the pupil dilation response (PDR) an objective measure for processing load. During a speech recognition task the PDR in 12 normal hearing young adults was recorded while they focused on either one or both of two sentences that were presented dichotically and masked by fluctuating noise. Dividing attention to process two sentences resulted in a larger PDR than processing only one. Additionally, we investigated how the PDR is influenced by prior knowledge of target speech location, onset, and who is going to talk. In total 56 normal hearing young adults performed a listening task similar to the previous one. In three separate experiments, target location (left or right ear), speech onset, and talker variability were manipulated by keeping these features either fixed during an entire block or by randomizing these over trials. The results showed a performance benefit when participants were able to focus on the target location and a decrease in PDR when focusing on location or talker. We conclude that communicating in a dynamic environment where multiple persons talk and walk around requires substantial listening effort because of the demands placed on attentional processes. How attention affect processing load in people with hearing loss will be addressed in future studies.
Neural Representations of the Cocktail Party in Human Auditory Cortex

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An auditory scene is perceived in terms of its constituent auditory objects, which in a “Cocktail Party” scenario correspond to individual speech streams. Here, we investigate how these auditory objects are individually represented in human auditory cortex, using magnetoencephalography (MEG) to record the neural responses of listeners to speech streams in a variety of auditory scenes. In the acoustically richest example, subjects selectively listen to one of two competing speakers mixed into a single channel. Individual neural representations of the speech of each speaker are observed, with each being selectively phase locked to the rhythm of the corresponding speech stream, and from which can be exclusively reconstructed the temporal envelope of that speech stream. The neural representation of the attended speech, originating in posterior auditory cortex, dominates the responses. Critically, when the intensities of the attended and background speakers are separately varied over a wide intensity range, the neural representation of the attended speech adapts only to the intensity of that speaker, but not to the intensity of the background speaker. Additional acoustic scenes investigated include speech masked by noise, including the case where the sounds are processed by (simulated) cochlear implants. Overall, these results indicate that concurrent auditory objects, even if spectrally overlapping and not resolvable at the auditory periphery, are indeed neurally separated and encoded individually as objects, in higher order auditory cortex.
Abstracts

Tuesday
The interactions between verbal short-term memory, speech perception and audition

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Verbal short-term memory has traditionally been considered as a cognitive function independent of sensory processes. More recent, interactive accounts ground short-term memory in language and attention processing. These accounts allow for both bottom-up and top-down dependencies between auditory sensory processing and verbal short-term memory, with language and attentional processes as mediator variables. I will discuss the different interactions that may link linguistic, attentional and auditory-verbal sensory processing in short-term memory situations and I will illustrate these interactions by findings from developmental and neurodevelopmental populations.
Performing a secondary task while listening to speech has a detrimental effect on speech processing, but the locus of the disruption within the speech system is poorly understood. Recent research has shown that cognitive load imposed by a concurrent visual task increases dependency on lexical knowledge during speech processing. However, this 'lexical drift' under cognitive load appears to be a secondary consequence of impoverished sub-lexical processing rather than a genuine increase in lexical activation. Furthermore, new evidence suggests that impoverished sub-lexical processing cannot simply be reduced to increased randomness in responding or disengagement in the task. What remains unclear, however, is whether impoverished sub-lexical processing under cognitive load corresponds to an actual disturbance of auditory processes or to reduced attention to the output of otherwise unaffected auditory processes. To adjudicate between these two alternatives, we measured brain activity in areas associated with early acoustic-phonetic processing and in areas associated with central control of attention while participants performed a speech-perception task under low versus high visual cognitive load. The results showed a clear suppression of brain activity under high cognitive load in auditory areas associated with early speech encoding (pSTS, pSTG) and no evidence that cognitive load affected frontal areas. While the mechanism by which cognitive load disrupts low-level speech perception remains to be specified, our results clearly show that cognitive interference takes place as early as in the initial encoding of the auditory signal.
Anticipation of what’s coming up next: working memory and processing speed mediate predictive language processing

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It is now well established that anticipation of upcoming input is a key characteristic of spoken language comprehension. Several mechanisms of predictive language processing have been proposed. The possible role of mediating factors such as working memory and processing speed however has not been explored in great detail. Furthermore, studies that have investigated individual differences in predictive processing have mainly focused on prediction of semantically fitting or associated referents. We conducted an eye-tracking experiment and administered several control tasks to assess whether working memory, processing speed, age, hearing sensitivity and non-verbal intelligence independently contribute to language-mediated anticipatory eye movements in adult native speakers of Dutch. The only cue participants could use for anticipation of upcoming referents was a gender-marked definite article (“de” or “het”, both translated as "the"). Participants (N=105) from 32 to 77 years of age received spoken instructions (e.g., "Kijk naar de afgebeelde piano" – Look at the displayed piano) while viewing four objects.

As the definite article agreed in gender only with the target, participants could use the article gender information to predict the upcoming target object. The average participant anticipated the target objects in advance of the critical noun. Multiple regression analyses showed that working memory and processing speed had the largest mediating effects: Enhanced working memory abilities and faster processing speed supported anticipatory spoken language processing. Our results are consistent with the notion that working memory and speed ground language in space and time, linking linguistic and visuo-spatial representations.
Predictive coding and the perception of degraded speech

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Human listeners are better than machines at perceiving and comprehending speech – particularly if the speech signal is acoustically degraded or ambiguous. Two processes that contribute to this success are that human listeners are: (1) more effective at using higher-level expectations (e.g. language knowledge) to support perception and (2) more flexible in adapting to unusual speech sounds, words and meanings. In this talk I will argue that a predictive coding account of speech perception can explain both of these processes. This account is supported by behavioural, MEG/EEG and multivoxel pattern-analysis fMRI experiments using noise-vocoded spoken words. (1) Prior knowledge (due to matching written text) and increased sensory detail (more vocoder channels) produce a similar enhancement of subjective speech clarity but have opposite effects on neural measures such as the magnitude of MEG/EEG responses and the representational content of fMRI responses in the Superior/Middle Temporal Gyrus. (2) Longer-term perceptual learning is supported by trials in which degraded speech follows matching prior knowledge and produces MEG/EEG response reductions in the STG following learning. Hence, neural processing of degraded speech is modified similarly by prior knowledge and perceptual learning and these two manipulations have a neural effect that is opposite to those observed when sensory clarity is increased by acoustic manipulations. These findings are uniquely consistent with a predictive coding account and provide important insights into how cognitive and sensory factors combine to determine listening outcomes in adverse conditions.
Tuesday June 16, 10.30–10.50

Predicting speech-in-noise perception using the trail making task: Results from a large-scale internet study

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The purpose of this study was to investigate the utility of an internet-based version of the trail making test (TMT) to predict performance on a speech-in-noise perception task. Computerised versions of the tests were completed, via the internet, by a large (1500+) sample of listeners aged between 18 and 91 years old, both with and without hearing loss. The results show that better performance on both the simple and complex versions of the TMT are associated with better speech-in-noise recognition scores. The findings suggest that the relation between performance in the TMT and speech recognition test may be due to the capacity of the TMT to index perceptual speed, as opposed to the more complex cognitive abilities also implicated in TMT performance.
Tuesday June 16, 10.50–11.10

Cognitive factors in the comprehension of dynamic conversations

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It is well established that as the speech signal gets degraded due to a hearing impairment, noise, or other distortion, more cognitive resources, particularly working memory resources, are engaged in recognising speech. Consequently, fewer resources, referred to as cognitive spare capacity, remain for higher level processing of speech such as comprehension, inference making, gist formulation, and response preparation. Most studies showing a relationship between working memory and speech understanding under adverse listening conditions have focused on a single talker in a fixed location (mostly directly in front of the listener). However, everyday communication often involves more than one talker. As the number of talkers grows there are more frequent changes in voice and location, and turn taking becomes less predictable. In this presentation, we introduce a novel dynamic speech comprehension test that simulates monologues and dynamic dialogues between two and three spatially separated talkers under very realistic acoustic conditions. We further show how working memory capacity and cognitive spare capacity relate to comprehension performance when the number of target changes from one to two to three talkers. Working memory was measured with the reading span test, while cognitive spare capacity was measured with a newly developed auditory test that taps into the executive updating parameter. Data collected on 30 normal-hearing participants tested in a simulated reverberant cafeteria noise will be presented and discussed. Preliminary data on hearing-impaired participants tested unaided and aided will also be presented and discussed.
Auditory Brainstem Implants and Speech:
Implications for Brain Plasticity

Robert V. Shannon

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Cochlear implants (CI) present auditory information in a spectrally degraded fashion. In spite of the coarse representation that may be tonotopically shifted and distorted, both adults and children learn to use the information that is presented optimally. Auditory Brainstem Implants (ABIs) activate the cochlear nucleus in the brainstem in a decidedly non-tonotopic manner. Post-lingually deafened adults and children can still use this distorted and tonotopically scrambled information to recognize phonemes and speech. But not all ABI recipients can achieve speech recognition with this information. This talk will provide an overview of outcomes from these different prostheses and patient populations and discuss the implications for brain plasticity.

Cochlear Implants in adults and children. CI provides degraded version of normal pattern of activity. Tonotopic order of cochlea preserved. Cochlear spacing preserved. Adults must map these new degraded patterns of activity to stored patterns from prior hearing. Children must learn these new patterns. Almost all patients do this optimally.

ABI in adults with prior hearing. ABI provides patterns of activity that are scrambled in terms of tonotopic order and spacing compared to normal hearing. Their brains must learn to map the new and distorted ABI information onto the patterns in their brain set up from their prior normal hearing. At first the sounds are strange, but after a few months they sound more normal. Still, some can do it but many cannot.

ABI in congenitally deaf children. ABI provides patterns of activity that are scrambled in terms of tonotopic order and spacing compared to normal hearing. Their brains must learn a completely distorted and scrambled pattern of activity and relate those patterns to sounds in the world, including speech. Some children can do this well, learning to understand and produce speech.

Implications for the Brain. New patterns of activation can be mapped onto previously learned patterns, even in adults. Completely new patterns of information can be learned in congenitally deaf. Whole new sensory representation (more than learning new language). Information content must be there. Distinct elements (channels). Consistent representation. Best outcomes in very young brains. But some children and adults cannot distinguish phonemes and recognize words with ABI. Why not? What anatomical differences might cause these differences?
Patterns or regularities in on-going sound sequences are key cues to understanding complex auditory environments. The pattern of sound often conveys the identity and state of objects within the scene and also enables the listener to predict future events, supporting efficient interaction with the surrounding environment. In my presentation I will review recent behavioral and brain imaging findings from my lab that demonstrate just how sensitive we are to complex sound patterns, including those that we have never previously encountered and, indeed, maybe unlikely to encounter outside of the laboratory. Our findings suggest that the auditory brain is a remarkably well-tuned ‘pattern seeker’, continuously scanning the unfolding auditory input for regularities, even when listeners’ attention is focused elsewhere. Brain responses reveal online processes of evidence accumulation - dynamic changes in tonic activity precisely correlate with the expected precision or predictability of ongoing auditory input – both in terms of deterministic (first-order) structure and the entropy of random sequences. Source analysis demonstrates an interaction between primary auditory cortex, the hippocampus and inferior frontal gyrus in the process of ‘discovering’ the regularity within the ongoing sound sequence. The results are consistent with precision based predictive coding accounts of perceptual inference and provide compelling neurophysiological evidence of the brain’s capacity to encode high order temporal structure in sensory signals.
Brain activity is governed by neural oscillations in different frequency bands. A guiding hypothesis from our laboratory is that slow neural oscillations (~4 Hz) index the degree to which a listener’s brain is able to faithfully track behaviourally relevant stimuli such as speech. Complementary, the power of alpha oscillations (~10 Hz) reveals the extent to which a listener deploys domain-general control processes to overcome listening challenges. I will present behavioral data as well as recordings of neural activity from magneto- and electroencephalography (M/EEG) that reveal distinct patterns of brain oscillatory dynamics at an older age and with progressive hearing loss: First, slow neural oscillations in younger and older listeners are robustly entrained by the rhythmic characteristics of speech (i.e., envelope fluctuations). However, older listeners are exhibiting this entrainment in a less flexible, task-dependent way. Second, enhanced alpha power during effortful listening indicates an increased need for attentional control across age groups. Older listeners show also altered alpha power dynamics with changing acoustic conditions, suggesting a decline in attentional control at an older age. Lastly, I will present initial evidence that, among older listeners, alpha power scales with the severity of hearing loss. These findings foster new perspectives on the neural underpinnings of listening effort and open up possibilities for re-thinking intervention and training in the older and hearing-impaired.
The cortical analysis of speech-specific temporal structure revealed by responses to sound quilts

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Speech contains temporal structure that the brain must analyze to enable linguistic processing. To investigate the neural basis of this analysis, we used sound quilts – stimuli constructed by shuffling segments of a natural sound, approximately preserving its properties at short timescales while disrupting them at longer scales. We generated quilts from foreign speech to eliminate language cues and manipulated the extent of natural acoustic structure by varying the segment length. Using fMRI, we identified bilateral regions of the superior temporal sulcus (STS) whose responses varied with segment length. This effect was absent in primary auditory cortex and did not occur for quilts made from other natural, or acoustically-matched synthetic sounds, suggesting tuning to speech-specific spectrotemporal structure. When examined parametrically, the STS response increased with segment length up to ~500 ms. The results identify a locus of speech analysis in human auditory cortex, distinct from lexical, semantic, or syntactic processes.
Deprivation from both ears arrests auditory development, driving cortical reorganization to help children who are deaf live in a world without sound. Auditory prostheses, including cochlear implants, aim to limit these changes from normal development by providing implants early in life. Yet, cochlear implantation of one ear can still leave the other ear deprived of sound. When this extreme condition of asymmetric hearing occurs in early development, the bilateral auditory pathways develop a preference for the hearing ear. This preference, found in the brainstem and cortex, begins after a mere 1.5 years of unilateral stimulation and appears to be further established once the cortex matures. Bilateral cochlear implants provided prior to this initial period of asymmetry protect the auditory system from such reorganization.

Present data reveal that children provided with bilateral implants simultaneously and sequentially have benefited from bilateral hearing and made remarkable advances in abilities to detect binaural cues. Unfortunately, however, they are using these cues differently than normal. For example, their perception of a fused input of sound coming from the two implants is often impaired. This may relate to the use of independent devices which are not well matched in pitch, level, and timing in addition to developmental asymmetries resulting, in part, from sequential treatment of one ear before the other.

In ongoing studies, we are examining the consequences of asymmetric hearing in children using one cochlear implant and a hearing aid in the other ear (bimodal users). Preliminary findings confirm expectedly large mismatches in timing in the brainstem but unexpected variability in asymmetric function along the bilateral auditory pathways measured by brainstem and cortical responses. These results reflect a fascinating cohort of children who had variable access to bilateral input at important early stages in development.

In sum, present research indicates that it is essential to provide auditory input during early stages of development and that input should be accessible from both ears. How best to provide this bilateral input is a question which remains the basis of our ongoing investigations.
The importance of listening effort in understanding degraded speech has received considerable attention in recent literature, particularly in light of its relevance to hearing assessment and rehabilitation. Previous studies have shown that changes in alpha oscillations are associated with cognitive load during complex speech perception tasks, and it has been suggested that changes in alpha might represent factors associated with listening effort (e.g., attention and working memory). In this study, we compared changes in alpha power (measured from Pz) during speech recognition tasks (monosyllabic words or sentences in 4-talker babble noise) for 22 normal hearing adults and 9 adult cochlear implant (CI) users, with speech recognition performance. Further, associations between changes in alpha power, performance, and measures of cognition (using BrainGauge in normal hearing adults or a reading span test in CI users) were investigated. Results suggest that changes in parietal alpha power were related to performance on speech recognition tasks in noise in normal hearing adults and adults with a CI. Further, the speech recognition scores in normal hearing adults were correlated with cognition scores, but a relationship between working memory and speech recognition scores was not evident in adults with a CI. In conclusion, the current study suggests that alpha power is related to performance on a speech recognition task and this might be mediated, at least in part, by cognition. The clinical implications for assessing listening effort in a clinical setting in combination with standard speech perception tasks will be discussed.
Abstracts

Wednesday
Listening, is it all in your head?
Cognitive training for adult hearing aid users

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For training interventions to benefit people with hearing loss, any task-specific learning needs to transfer to functional benefits in real-world listening. Our previous auditory training studies suggest that the real-world benefits of auditory training are associated with the development of top-down cognitive processes. A double-blind randomized active-controlled trial of 62 adult hearing aid users with mild-moderate hearing loss assessed the benefits of working memory training to cognition, speech perception and communication. Participants were randomized into two groups (n=31 per group) and trained online for 5-weeks using the Cogmed RM working memory program. The adaptive training group (Trained) trained using span-based verbal and visuospatial working memory and storage tasks, where the number of to-be-remembered items increased adaptively based on individual performance. The active-control group (Control) trained using the same tasks, fixed at a sequence length of 3-items. Five participants did not complete the study (n=4 Trained, n=1 Control). For the Trained group, on-task learning was highly variable (Cogmed index = 9.74-38.84). Post-training improvements were shown for a trained working memory task (backwards digit span, p<.001). Near-transfer of learning was shown for an untrained working memory task (visual letter monitoring, p<.001). There was no far-transfer of learning to measures of speech perception performance (MCRM, IHR-SPIN). Results suggest that it is not possible to train the cognitive components of speech perception in isolation. It is argued that training interventions that target cognition embedded within auditory tasks are most likely to offer generalized benefits to the real-world listening abilities of people with hearing loss.
Effective communication in challenging conditions relies in part on listeners’ ability to quickly adapt to variation in the acoustic signal. I will focus on two types of variation, namely accent variation and noise-vocoded speech signals. When a listener is presented with speech in an (unfamiliar) accent, speech recognition becomes initially slower and less efficient, before the listener quickly (usually over the course of < 20 sentences) ‘tunes in’ to the phonetic and phonological variation in the accent, as evidenced by improved speech recognition performance. A similar behavioural pattern is generally observed for adaptation to noise-vocoded speech. The cognitive and neural mechanisms supporting the ability to quickly adapt to unfamiliar variation in speech have been examined in a wide variety of studies in recent years. These studies have employed a wide variety of methods; including behavioural experiments, eye-tracking paradigms, as well as cognitive neuroscience approaches including fMRI. In addition, as the ability to adapt to accent variation varies considerably across listeners, my collaborators and myself have also investigated this issue by comparing accent perception in different age groups, or by relating differences in adaptation ability to individual differences in cognitive capacity resources such as working memory, vocabulary knowledge, or selective attention. Finally, we have studied how available visual information is used in the adaptation process using eye-tracking paradigms. In my talk, I will discuss patterns emerging from these studies as well as their implications for the relationship between individual cognitive abilities and effective speech processing.
In many countries, congenital hearing impairment (HI) in children is detected soon after birth through neonatal screening provided by the hospital and/or “child-supporting center”. Early identification of HI and subsequently, early intervention are proven to be the most important predictors for the development of spoken language skills. However, even a relatively homogeneous sample of children (eg implanted at the same early age) demonstrates a wide variety in performance on auditory, linguistic, cognitive tasks, as well as speech perception in noise. It is speculated that the causes of this variability are likely to lie beyond hearing aid/cochlear implant technology.

This presentation will first summarize what can be expected of normally developing children with CI(s) with regard to spoken language, bilateral and binaural auditory perception, speech perception and cognitive skills. Subsequently, similar outcome measures will be presented of children with unilateral hearing impairment, who are often assumed to develop language skills as well as their normal hearing peers. Our data show that children with unilateral hearing impairment lag behind on some developmental outcomes, and that these should be addressed at a young age in order to obtain age-adequate performance. These issues, as well as data on hearing screening at pre-school age are discussed. Understanding the strengths and weaknesses in different skills of children with different degrees of deafness will allow us to develop or improve targeted interventions.
Cross Modal Plasticity in Children with Cochlear Implants: An Event Related Potential Study

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Deaf children who receive a cochlear implant early in life and engage in intensive oral/aural therapy often make great strides in spoken language acquisition. However, despite clinicians’ best efforts there is a great deal of variability in language outcomes. One concern is that cortical regions that normally support auditory processing may become reorganized for visual function. The conditions under which these changes occur are not understood. We collected auditory and visual evoked potentials from 22 deaf children (ages 1 year-8 years) with cochlear implants. Auditory stimuli consisted of an odd-ball paradigm (85% /ba/ syllables vs. 15% FM tone sweeps) to elicit a P1-N1 complex. Visual evoked potentials were recorded to an intermittent peripheral radial checkerboard while children watched a silent cartoon eliciting a P1-N1-P2 visual evoked potential (VEP) response. Using published norms of auditory P1 latencies (Sharma & Dorman 2006), we categorized deaf children as showing normal (n=14) or abnormal auditory development (n=8). Results indicate that deaf children with abnormal auditory responses were more likely to have abnormal visual evoked potentials (8/8) compared to deaf children with normal auditory latencies (3/14). The aberrant responders showed a VEP off-set response that was larger than the VEP onset response (a pattern opposite of what is normally observed). VEP data show an unusual topographic distribution with extension to midline site Cz. These data suggest evidence of cross-modal plasticity in deaf children with cochlear implants. We discuss the contributions of signed and spoken language experience in the expression of these results.
In the last 30 years, many studies have shown that deprivation of one sense alters and/or enhances the remaining senses, with blind people hearing better and deaf people seeing better, and it is believed that these changes are adaptive. However, there is controversy surrounding under what task conditions sensory enhancement in deaf individuals is observed. In this talk, I will summarize a series of psychophysical studies from my laboratory investigating visual perception and attention in deaf and hearing adults and children, teasing apart whether group differences are due to deafness per se or experience with a visual language. We studied several aspects of vision (motion, orientation, and brightness) under conditions of “divided” attention and “selective” spatial attention. Divided attention was studied using a dual task paradigm, which we addressed by measuring visual performance under full vs. poor attention conditions. Selective spatial attention was studied using a spatial pre-cueing paradigm. Finally, we examined visual field lateralities in these groups as well, to examine whether deafness or sign language experience have impacts on hemispheric laterality of visual abilities and attention.
Wednesday June 17, 11.20–11.40

A working memory role for superior temporal cortex in deaf individuals independently of linguistic content

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Studies of sign languages have been used to test traditional cognitive models of working memory (WM) that distinguish between verbal and visuospatial WM (e.g. Baddeley, 2003), without considering that sign languages operate in the visuospatial domain. Previous studies have shown that WM mental representations and processes are largely similar for signed and spoken languages (e.g. Rönberg et al., 2004). However, it is not clear to what extent visual WM processes aid and support sign language WM.

Here we characterise the neural substrates supporting sign language and visual WM, and the mechanisms that subserve differential processing for signers and for deaf individuals. We conducted a functional magnetic resonance imaging (fMRI) experiment with three groups of participants: deaf native signers, hearing native signers and hearing non-signers. Participants performed a 2-back WM task and a control task on two sets of stimuli: signs from British Sign Language or nonsense objects. Stimuli were composed of point-lights to control for differences in visual features.

Our results show activation in a fronto-parietal network for WM processing in all groups, independently of stimulus type, in agreement with previous literature. We also replicate previous findings in deaf signers showing a stronger right posterior superior temporal cortex (STC) activation for visuospatial processing, and stronger bilateral STC activation for sign language stimuli. Group comparisons further reveal stronger activations in STC for WM in deaf signers, but not for the groups of hearing individuals. This activation is independent of the linguistic content of the stimuli, being observed in both WM conditions: signs and objects. These results suggest a cognitive role for STC in deaf signers, beyond sign language processing.
Working memory for manual gestures is influenced more by poor visual resolution when working memory load is high

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Working memory (WM) capacity for speech is reduced when the input signal is degraded. However, little is known about the effect of degraded input on WM for sign language. We investigated how visual resolution interacts with WM load. Twenty sign language naive participants with a mean age of 22 years (SD 1.8), normal visuospatial cognition and no reported hearing or vision problems took part in the study. They viewed series of video-recorded manual gestures that were lexicalized in sign language presented at one of five different levels of resolution and performed an n-back task where n was either one (low load) or two (high load). All participants performed the task with all five levels of resolution at both load levels in pseudorandomized order. They also performed a WM task (operation span). A repeated measures analysis of variance revealed significant main effects of load and resolution as well as a significant interaction showing a greater effect of reduced resolution when load was high. Operation span correlated significantly with n-back performance and there was evidence that participants who played computer games compared to non-players were less sensitive to reduced resolution when load was high. These results suggest that reduced visual resolution interferes with the cognitive representation of manual gestures but that experience with cognitive processing of visual information may mitigate this effect. Future work should investigate whether sign language users are protected against the effect of reduced visual resolution on cognitive representation of manual gestures.
Posters
Brain morphometry of adults with hearing impairment

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Understanding speech depends on the successful interaction of sensory and cognitive abilities. Aging is associated with both hearing loss and cognitive decline. How peripheral hearing loss is related to brain structures associated with speech processing, independent of the gradual atrophy of the aging brain, is unclear. In this exploratory study, we compared T1 weighted structural magnetic resonance images of 17 hearing impaired individuals with those of 17 normal hearing individuals in a voxel-based morphometry analysis. Participants were individually matched based on age and education. Gray and white matter volumes were compared through whole-brain analyses and region-of-interest analyses for structures associated with speech processing. Preliminary results suggest that hearing impairment may be associated with volume differences in areas located in temporal and parietal regions, including angular gyrus and occipitotemporal gyrus. These areas are associated with extracting meaning from language and recognizing words, respectively. We discuss possible mechanisms through which the mentioned differences can be explained.
Decades of research in attention have focused almost exclusively on visual attention under the presumption that attention is essentially supra-modal in nature. Current tests that include measures of “auditory” attention are all based on verbal processing, so little is known about attention to non-speech sounds. To address this we developed a novel Test of Attention in Listening (TAiL). The TAiL captures aspects of selective attention such as involuntary orientation (distraction by an unattended stimulus feature) and conflict resolution in addition to more general processing efficiency. It employs a simple two-tone paradigm, requiring a same-different speeded response based on either tone frequency or location (ear of presentation).

We present data showing that the TAiL measures are replicable in several independent adult samples, and can be successfully used in children as young as 4 years as well as older, hearing impaired adults.

We assessed the TAiL’s validity by comparing it to other widely-used tests of attention (e.g. the Attention Networks Test), and present evidence that it taps into both modality-specific and domain-general processes. A factor analysis showed that attending to frequency is auditory-specific, while attending to location, together with aspects of visual attention and processing efficiency measures, loads on domain-general factors.

Finally, we present data showing that while reaction times reduced upon repetition of the TAiL, its reaction-time difference measures of involuntary orientation and conflict resolution remain unchanged when re-tested immediately, one week or three weeks later.
Greater reliance on magnitude manipulation during mental arithmetic in deaf signers compared to hearing non-signers: fMRI evidence

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Evidence suggests that the lag reported in mathematics for deaf signers derives from difficulties related to verbal processing of numbers, whereas magnitude processing seems unaffected by deafness. Neuroimaging evidence from hearing individuals suggests that verbal processing of numbers engages primarily left angular gyrus (lAG), whereas magnitude processing engages primarily the horizontal portion of the right intraparietal sulcus (rHIP). In a ROI analysis of brain imaging data from 16 adult deaf signers and 16 adult hearing non-signers, who did not differ on sex, age or education, we examined if activity in lAG and rHIP changed as a result of task (multiplication vs subtraction) and group (deaf signers and hearing non-signers). We found a significant main effect of brain region (\(F(1,30) = 117.00, p < .001, \eta_p^2 = .80\)) and an interaction effect between region and group (\(F(1,30) = 20.70, p < .001, \eta_p^2 = .41\)). Further analyses showed that there were no significant differences in average activation between groups in lAG (\(F(1,30) = 0.16, p = .70\)). However, in rHIP deaf signers showed significantly greater average activation compared to non-signers (\(F(1,30) = 15.20, p < .001, \eta_p^2 = .34\)). There were no significant differences in activation between subtraction and multiplication (\(F(1,30) = 0.66, p = .42\)) and no behavioural differences between groups (\(F(1,30) = 1.70, p = .20\)). These results suggest that when engaging in arithmetic tasks deaf signers successfully make use of qualitatively different processes, compared to hearing non-signers, with stronger emphasis on brain regions relating to magnitude manipulation.
Sound perception is a fundamental part of our interactions with and experience of the external environment. We receive considerable amount of information from our surroundings through sounds. The auditory system takes care of this continuous flow of information in a seemingly effortless manner. It functions as an adaptive and cognitive alarm system that scans our surroundings, detects and analyzes the significant events, and signals for attention shifts to objects of interest. In a series of experiments, we explored how the affective qualities of auditory stimuli may modulate the way we attend to and perceive the sounds around us. First, using an affective-learning paradigm, we investigated whether learned emotional meaning of an otherwise meaningless sound could influence the perception of loudness. Second, we studied, using a covert-spatial-orienting task, whether the emotional salience of sounds can provide exogenous cues for the orientation of spatial attention. Finally, in a change-detection experiment, we investigated the role of the emotional information for the auditory perception/attention in the presence of a complex environment with a number of concurrent sounds.

Overall, the experiments presented clear behavioral evidence that emotional salience of sounds influenced the loudness perception and the orientation of auditory spatial attention, and that the auditory attention in a complex environment is guided by the emotional significance of events taking place within that environment.

Taken together, we argue that the emotional salience provides cues for the allocation of attention in the auditory modality, and that the affective experience is integral to auditory perception.
Examining the effects of listening effort and grammatical complexity using self-paced listening

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Cognitive load while listening to speech can be engendered by the content complexity of the speech materials as well as by poor listening conditions. One such example comes from sentences that contain structural uncertainty at a certain point within a sentence. For example, a sentence beginning with “They heard the story...” introduces two possible syntactic structures. In a direct object structure, “the story” functions as the direct object of the verb “heard” (e.g., “They heard the story briefly.”). In a sentence complement structure, however, “the story” functions as the subject of the sentence complement (e.g., “They heard the story was true.”). Because verbs such as “heard” occur statistically more frequently with a direct object sentence structure, hearing “the story” followed by a verb phrase represents a less likely, low-expectancy structure. To examine the effects of such grammatical complexity on speech processing, we presented recorded sentences with the input periodically interrupted after words or phrases. Listeners were instructed to use a key-press when they felt ready to hear the next segment. Increased pause durations when listeners encounter structural uncertainty was taken as a measure of syntax-induced processing load at that point. If listening effort engages a detailed syntactic analysis, effortful listening in older adults with age-related hearing loss should result in differentially longer pause times when a sentence continuation violates verb bias relative to older or young adults with normal hearing. Results will be discussed in terms of the interaction between listening effort and syntactic effects on sentence processing.
Auditory perceptual challenges (e.g., background noise, rapid speech rates) are detrimental to speech recognition, especially when non-native listeners are concerned. The major goal of the current study was to determine whether differences in the perceptual learning of time-compressed speech between native and non-native listeners are associated with the greater difficulties faced by non-native listeners in this task. The potential contributions of rapid perceptual adjustment and slower training-induced learning were considered. The identification of time-compressed sentences was compared between native and non-native listeners (n = 30 in each language group) who trained on the semantic verification of time-compressed sentences for three sessions, listeners who were briefly exposed to 20 time-compressed sentences and naive listeners. Recognition was assessed with three sets of time-compressed tokens intended to assess learning of specific tokens as well as the generalization of learning to different tokens and to a different talker. Rapid perceptual adjustments and training-induced learning were both influenced by language experience. First, rapid perceptual adjustment was weaker in non-native listeners than in native listeners. Second, although training-induced learning and across-talker generalization were robust in both native and non-native speakers, generalization to untrained tokens was reduced among non-native speakers. These data suggest that the perceptual learning mechanisms of speech are sensitive to linguistic experience and that in a non-native language is perhaps more token-specific. Therefore, non-native listeners may require longer periods of practice to achieve native-like levels of generalization, consistent with their difficulties in challenging real-life conditions.
Individual differences in eye gaze during audiovisual sentence recognition

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Visual information from a speaker’s face improves speech recognition in adverse listening conditions (Sumby & Pollack, 1954). Most research into this phenomenon has examined audiovisual speech recognition across multiple words or sentences, focusing on group effects. However, little is known about audiovisual speech recognition within particular items, for example exactly when visual information is gained and used during recognition of individual sentences, and whether this varies between individuals. Using eye-tracking, we investigated individual differences in audiovisual speech processing during recognition of individual noise-vocoded sentences. We observed that eye gaze towards a speaker’s mouth increased as the sentence was presented, with a peak at around 3000ms after onset, whereas eye gaze towards a speaker’s eyes remained stable. Fewer saccades (eye movements) and longer fixations during the first 1000ms were observed in listeners who had poorer recognition accuracy of the sentence. Our results suggest that use of visual speech information is a dynamic process that varies between individuals, even within individual sentences; that is, listeners rapidly modulate their eye gaze to compensate for poor auditory input, and those who have poorer recognition look more at a speaker’s mouth at sentence onset than those with better recognition.
Sensitivity of BESST-UK sentences to differences in children’s listening abilities

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The SPIN sentence-pair test (Bilger et al, 1984) separately assesses contributions to successful listening in noise from speech discrimination versus cognitive/linguistic abilities. Sentence pairs share the same final single syllable word, but differ in the ease with which this word can be predicted from the preceding context.

We recently developed the BESST-UK sentence pair test. Here, we consider its suitability for assessing individual differences in speech-in-noise listening in children aged 8 to 10 years. The children were subdivided using the ECLiPS (Barry & Moore, 2014) according to whether they were typically-developing (TD-Child) or had listening difficulties (AP-Child). BESST-UK sentences were presented in a British English four-talker babble at a high (+2dB) and low (-2dB) SNR. Listeners (young adults, n = 18; TD-Child, n = 14; AP-Child, n = 13) repeated each sentence and the number of correct sentence final words for each group was compared.

The Child-AP group made more errors on all sentence types than the Child-TD group, who in turn made more errors than the adults particularly in the unfavourable SNR. Both groups of children made more errors in the low SNR and seemed to benefit less from sentence context than the adults in this condition. The Child-AP group performed equally poorly regardless of relative predictability of the final word. This suggests listening support from language abilities (high predictability sentences) cannot offset their greater speech perception difficulties (low predictability sentences).

Overall, the BESST-UK sentences can be used with different child populations and can provide interesting insights into age and disorder-related listening difficulties.
Influences of auditory temporal and cognitive processing on speech understanding depend on masker type and hearing status

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Influences of auditory temporal and cognitive processing were investigated for speech understanding in steady-state noise (SRTSTEADY), fluctuating noise (SRTFLUCT), and with an interfering talker (SRTTALKER). Two groups of older listeners participated, either with normal hearing (ONH; N = 36; 51-70 years) or a sensorineural hearing loss (OHI; N = 36; 45-83 years). To account for elevated pure-tone thresholds, speech stimuli were spectrally shaped according to the individual audiogram. Predictors for the three SRT outcome measures were determined from a set of measures assessing the ability to process temporal-envelope, F0-periodicity, and temporal fine-structure (TFS) cues, and from the assessment of verbal working memory span (listening span), linguistic closure abilities (text reception thresholds), general cognitive ability, and audiometric thresholds. In the ONH group, SRTSTEADY scores were not predicted by the included measures, SRTFLUCT scores were predicted by age and listening span, and SRTTALKER scores by TFS processing and listening span. In the OHI group, SRTSTEADY scores were predicted by TFS processing, SRTFLUCT scores by age and temporal-envelope processing, and SRTTALKER scores by listening span and audiometric thresholds at higher frequencies. Accordingly, masking condition and hearing status determine the pattern of suprathreshold contributions to speech understanding.
The purpose of this study was to explore how self-reported tinnitus correlates with 20 years longitudinal thresholds shifts for hearing loss in a male twin cohort. A cohort of male twins (n=1114 at baseline and n=583 at follow-up) were sent a questionnaire including questions regarding tinnitus on two occasions with approximately 20 years between baseline and follow-up. Pure-Tone Threshold (PTT) audiometry (0.125-8 kHz) was measured by an audiologist at both time points. In the 576 subjects who had completed both the questionnaire and the PTT audiometry at both time points, we compared the PTT data and the self-reported tinnitus in a longitudinal perspective. Hereditary analyses for tinnitus were performed with threshold liability model and mixed model for comparing groups with different tinnitus status. The group who never reported tinnitus had less hearing deterioration during a 20 years follow-up period compared with those who had reported tinnitus at follow-up (3-8 kHz) and also compared with those who reported tinnitus at both time points (1-3 kHz). Preliminary results from ongoing analyses of self-reported tinnitus seems to confirm a moderate genetic influence for tinnitus.
Tuning in on the target: 
The influence of hearing impairment on 
the neural encoding of speech

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Processing of speech can be demanding in situations were the auditory input is degraded, either by external noise or internal loss of hearing. The incoming speech is processed and interpreted in the brain and it is has been shown that manipulations of the auditory input can be detected in the electroencephalogram (EEG). Studies have shown that the dynamics of attended speech, as well as target distractors, is encoded by the brain, i.e., the speech envelope can be recognized in the EEG signal. However, the effect of hearing impairment on the encoding has not yet been addressed.

In a listening task, participants with varying degrees of hearing impairment listened to 12 minutes of continuous speech. In intervals, the target speaker was presented in quiet or interrupted by noise at three different signal-to-noise levels. We will present data showing that the speech envelope was detectable in the EEG of the elderly hearing impaired participants. We hypothesize that disturbance from the masking noise will have a negative influence on the encoding of the target envelope. Likewise, we expect to find that worse hearing has a negative effect on the encoding of the target envelope. Such findings suggests that the higher effort often reported to accompany hearing impairment, could be influenced be a poorer target envelope encoding, requiring more working memory involvement to be successfully understood.
Cochlear implant users’ auditory diet: Analysis of a large sample of automatically collected data

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For persons with a cochlear implant (CI) the auditory environment is crucial. Knowledge of the typical auditory diet of CI users is important to guide rehabilitation. Automatic data logging allows a reliable and comprehensive measurement of such variables. However, to date no large and representative sample of data logs of the auditory environment of CI users has been analyzed.

We did a retrospective cross-sectional analysis of automatically collected data logs from Nucleus 6 cochlear implant sound processors. The Nucleus 6 sound processor continuously analyzes the auditory environment of the wearer. It records the time spent in different acoustical scenes, the average sound pressure level and other usage related information. The data contains anonymized logs of 561 CI users from 45 clinics in North America and Asia Pacific, covering over 41,000 days of implant use. Age ranges from less than one to more than 90 years.

We investigated age and culture related differences in the auditory environment. Preliminary analysis of the data shows substantial changes in the exposure to noise and speech over the lifespan, as well as differences between Eastern and Western countries.

Our data provides important insights into the everyday acoustical experience of CI users. However, due to the underrepresentation of certain age groups and regions, and constraints from anonymization the conclusiveness of our data is still limited. Data collection will continue to fill these gaps and substantiate the analysis.
Consonant and lexical-tone discrimination in profoundly hearing-impaired French-children using cochlear-implants

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Cochlear-implant (CI) processors poorly transmit the voice-pitch information. Receptive and productive language difficulties have been highlighted in children using these devices and learning a tonal language (i.e., using voice-pitch variation at a syllable level). Whether this impact of CIs is specific to tonal-language learners and how non-tonal language learners would respond remains unknown. The present study explores the auditory and linguistic components of tone processing via CIs by evaluating how children using CIs and learning a non-tonal language (French) discriminate lexical tones versus consonant contrasts.

Eighteen native-French children (4 to 6;10 years) using CIs and 18 normal-hearing (NH) children matched in chronological age were asked to press a button when they heard a change within a background stimulus. In the consonant condition, the stimulus /aba/ was repeated and change syllables were either /ada/ or /apa/. In the lexical-tone condition, the stimulus /bá/ (rising tone) was repeated and change syllables were either /bà/-falling, or /ba/-flat low pitch.

Compared to NH children, CI users were significantly less accurate and slower at discriminating consonants (96% vs 72%; 1456ms SD=412 vs 2293ms SD=971, respectively) and less accurate with lexical tones (91% vs 75%, respectively). More surprisingly, CI-users were significantly faster at discriminating lexical tones than consonants (mean=1557ms, SD=518; mean=2293ms, SD=971, respectively).

Thus, French children using CIs are faster when discriminating non-native voice-pitch variations than native consonants. This result suggests that CI processors convey enough voice-pitch information to discriminate lexical tones but questions remain about the use of this information at a linguistic level.
Interaction between top-down spatial attention and cognitive load during dynamic conversational listening

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Following a multi-talker conversation relies on the ability to rapidly and efficiently shift the focus of spatial attention from one talker to another. This study investigated the top-down listening costs associated with shifts in spatial attention in 16 normal hearing listeners. Three pairs of syntactically fixed but semantically unpredictable matrix sentences, recorded from a single male talker, were presented concurrently through an array of three loudspeakers (directly ahead and +/-30°). Subjects attended to one spatial location, cued by a tone, and followed the target conversation from one sentence to the next using the call-sign at the beginning of each phrase. Subjects were required to report the last three words from each sentence or answer multiple choice questions related to the target material. There was a 10.7±1.3% decrease in word recall, a substantial primacy effect, a rise in masker confusion errors and an increase in word omissions when the target switched location between sentences. Switching costs were independent of the hemisphere, direction and angular size of the spatial shift but did appear to be load dependent- only significant for complex questions requiring multiple cognitive operations. Reading span scores were positively correlated with total words recalled, and negatively correlated with switching costs and word omissions. Task switching speed (Trail-B time) was significantly correlated with recall accuracy. Overall, this study highlights i) the listening costs associated with shifts in spatial attention and ii) the important role of working memory in maintaining goal relevant information and extracting meaning from dynamic multi-talker conversations.
Not speed but precision define lexical access efficiency of word recognition in noise

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Several researchers have suggested vocabulary size as a useful measure of “ver-bal abilities” that correlates with speech intelligibility scores. The more words a listener knows, the better his relative speech intelligibility scores. We confirmed this suggestion in a group of young listeners with normal hearing by correlating intelligibility test scores of a German everyday sentence test to a measure of vocabulary size ($R^2=0.503$). We also tested lexical access time and general processing time in a lexical decision test. Slow reaction time elicited by high frequency words correlated with vocabulary size ($R^2=0.47$), indicating that a larger number of competitors in the mental lexicon slows down processing time. Slow lexical access for low frequency words correlated with better intelligibility scores ($R^2=0.51$), indicating that listeners were more successful when applying precision rather than quick matching strategies. This counterintuitive observation may be related to the offline test design. If listeners are given the opportunity to rehearse the speech fragments they perceived before giving their answer, they may restore missing information and take longer for the lexical “matching procedure”. In an ongoing follow-up study, we therefore test whether the correlation of lexical access time due to offline rehearsal is modulated by working memory capacity. We compare these data to older listeners, who are assumed to have a larger vocabulary size, but whose working memory capacity may be reduced. Altered correlations of intelligibility scores with lexical knowledge and accessing speed across age groups may disentangle the influences of different cognitive factors on speech perception in noise.
Cognitive training and effects on speech-in noise performance in normal hearing and hearing impaired individuals

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Cognitive training might have potential to improve speech understanding under adverse listening conditions. Here, we have examined the effects of a 5-week computer-based cognitive training program on speech-in-noise-performance, in normal hearing (NH) participants and in participants with mild-to-moderate sensorineural hearing loss (HI).

Two groups, matched on gender and age (45-65 years), of 20 participants each (HI and NH respectively) are recruited. Participants perform four test-sessions; inclusion (t0), five weeks (t1), ten weeks (t2) and six months (t3). Training is performed either between to and t1, or between t1 and t2 (using a cross-over design), using the computer-based Cogmed training program, approximately 30-40 minutes per day, five days per week, during five weeks. At each session participants are tested in three different ways: (a) cognitive testing (KIPS, SICSPAN, TRT); (b) auditory performance (pure tone-audiometry (air- and bone-conduction) and speech audiometry (HINT, Swedish SPIN-test (SNR +4dB))); (c) cortical activation (MR sessions where participants performed a speech-in-noise task using Hagerman-sentences with steady-state speech-spectrum noise (SSN) and with two competing talkers). MR imaging is performed on a Philips Achieva 1.5 Tesla scanner using a sparse imaging technique in which stimuli are presented during the silent period between successive scans. Participants listen to auditory stimuli under eight different conditions: clear speech, SSN or two competing talkers (each at 90%, 50% and 0% intelligibility), and silent rest. Pre- and post-training, hearing disability is assessed by the Speech-Spatial-Qualities-Questionnaire.

The study is on-going and behavioral results as well as results from fMRI will be presented.
Modeling the effect of early ageing and hearing loss on cognition and participation in social leisure activities

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There are well-known age-related declines in hearing, cognition and social participation. Furthermore, previous studies have shown that hearing loss is associated with both cognitive decline and increased risk for social isolation and that engagement in social leisure activities is related to cognitive decline. However, it is unclear how the three concepts and age relate to each other. In the current study, behavioral measures of hearing and memory were examined in relation to self-reported participation in social leisure activities. Data from two different samples were analyzed with structural equation modeling. The first consisted of 297 adults from Umeå, Sweden, who participated in the Betula longitudinal study. The second consisted of 273 older adults who volunteered for lab-based research on aging in Toronto, Canada. Structural equation modeling yielded two models with similar statistical properties for both samples. The first model suggests that age contributes to both hearing and memory performance, hearing contributes to memory performance, and memory (but not hearing) contributes to participation in social leisure activities. The second model also suggests that age contributes to hearing and memory performance and that hearing contributes to memory performance, but that age also contributes to participation in social leisure activities, which in turn contributes to memory performance. The models were confirmed in both samples, indicating robustness in the findings, especially since the samples differed on background variables such as years of education and marital status. Few participants in both samples were candidates for hearing aids, but most of those who were candidates used them. This suggests that even early stages of hearing loss can increase demands on cognitive processing that may deter participation in social leisure activities.
Neonatal hearing screening has reduced the detrimental consequences of undetected and untreated sensorineural hearing loss on general development and academic achievement. However, not all childhood hearing problems are identified at birth. Therefore, a school entry hearing screen is imperative. Within this framework, the feasibility of a speech-in-noise test that uses digit triplets (Digit Triplet Test, DTT) was investigated in 30 preschool children (4;10-5;10y), thereby considering aspects of verbal working memory performance, general attention and mother tongue.

The children were tested in a test-retest design at their school. Testing included pure tone audiometry, tympanometry, monaural administration of the DTT and three working memory (WM) tasks (digit span forward, digit span backward and reciting series). Information regarding their native tongue and attention span was gathered via the parents.

Speech Reception Thresholds (SRT) as well as WM scores improved significantly between test and retest. Children with reported attentional difficulties had poorer SRTs in noise as well as lower WM scores. Poor WM performance was also associated with worse SRTs at the test session, but not at retest. Between native-Flemish children and non-native Flemish children, no difference in SRT was observed, however WM scores were lower in the latter group.

These results suggest a cognitive-auditory interplay that should be considered in the interpretation of the Digit Triplet SRT. The test procedure will be adapted with the aim of reducing attentional factors.
Introduction: The repetition of pseudo-words is not as simple a task as it seems. There needs to be adequate to be a greater discrimination of pseudo-word neural network. The literacy (ability to use the skills of reading, writing and arithmetic) promotes a change in the neural network, thus allowing a greater number of hits in the repetition of pseudo-words.

Objective: This study aims to discover which of the two groups, with the highest literacy (group of 35 to 45 years) and lowest literacy (group from 18 to 19 years), but both with 9th degree there is a greater number of hits in the repetition of words and pseudo-words.

Methodology: All subjects in the sample, after the inclusion criteria had to be subject to the presentation of two lists of words and two lists of pseudo-words, having to repeat the words and pseudo-words they heard.

Results: It was found that the higher literacy group had a greater number of hits, statistically significant differences both in the repetition of words (98%-89%) and pseudo-words (96%-77%). Although not statistically significant, also found that the group with lower literacy conducted more transformations of pseudo-words for words.

Conclusion: In short, literacy, provides better results in more complex activities and represent a new concept. In this case, people with a higher level of literacy had a higher number of correct answers in both words and pseudo-words.
The contributions of hearing and cognition vary for different speech perception tests

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Perceiving speech, particularly in noise, becomes more difficult as people age. Listeners vary widely as to their speech perception abilities even when hearing sensitivity, as measured by pure-tone audiometry, is similar. Cognition has emerged as a key concept to understand these changes. However, whether cognition affects all forms of speech perception similarly or whether its effects are more nuanced between different measures is unclear. This study investigated how performance on different speech perception tests relates to aspects of cognition, and how this relationship is mediated by hearing loss.

Forty-four listeners aged between 50-74 years old with mild sensorineural hearing loss completed speech tests that differed in complexity from low (phoneme discrimination in quiet) to medium (digit triplet perception in speech-shaped noise) to high (sentence perception in 8 Hz-modulated noise). Exploratory regression models examined the relationship between speech perception and cognition (i.e. working memory and attention), while controlling for hearing sensitivity.

There were differential associations between speech perception, hearing sensitivity and cognition. All speech tests, except phoneme discrimination, were associated with hearing sensitivity. For the digit triplet tests, only hearing made a significant contribution, while cognition did not. For sentence perception both hearing and cognition made significant contributions, more so for attention than working memory.

These results suggest that researchers and clinicians need to be aware that different speech perception tests vary in their auditory and cognitive demands. Specifically, as speech test complexity increases, attention and working memory contribute more to the explained variance in speech test performance than hearing thresholds.
Aim: to study the possibility that teenage musicians, of the 10th grade, have any benefit in speech processing and on the discrimination of pseudowords, compared to other teenagers of the same age, but without any kind of music practice, by using diverse technical equipment to evaluate the performance of each teenager in each task. Methods: after a signed consent from their parents so that each teenager could participate in this study, an Otoscopy was performed, alongside a Timpanogram, Contra-Lateral Stapedic Reflex and an Audiogram the frequencies of 1000Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz and 8000Hz, for inclusion in the study, after this was a Speech in Noise test was conducted, on 3 different condition, on a silent environment, with a signal-to-noise ratio of 0 dB and with a signal-to-noise ratio of +5 dB, using pink noise, and a Pseudowords Test at the end. Conclusion: relevant statistical differences were found, showing a benefit on speech processing and pseudoword discrimination on behalf of the musicians.
On the relationship between speech understanding and cognition in cochlear-implant users

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The aim of the present study is to investigate how cognitive/linguistic competence relates to speech understanding in cochlear-implant (CI) users. Reported differences in listening effort and CI performance in clinical speech tests might be related to working memory capacity (WMC) and/or linguistic competence. In contrast to clinical speech tests, electroencephalography (EEG) can provide insights into the neuronal processing of auditory stimuli. Early event-related potentials (ERPs) can give insights on the sensory processing of the stimuli while later ERPs represent higher levels of neural processing. The P3 component has been related to listening effort in normal hearing (NH) persons and CI users. In the present study, CI users’ verbal working memory and lexical fluency were tested. Subsequently, their speech intelligibility in quiet/noise was assessed while having their EEG recorded. We used an active oddball paradigm: Participants were asked to press a button every time they heard a rare target word (\(p = 0.2\)) intermixed in frequent standard words (\(p = 0.8\)).

Preliminary results revealed a relationship between WMC/linguistic competence and ERP latencies for CI users. We found effects of background noise on early and late ERPs with shortest latencies for speech in quiet. Only target words elicited a clear P3. Moreover, first results indicate a negative relation between the N1 latency and clinical speech test. The lexical fluency was negatively correlated with the N1 and N2 latencies. The study is a first step towards the combined investigation of speech intelligibility, listening effort and individual cognitive/linguistic competence in CI users.
Impact of Otitis Media with Effusion on everyday cognitive functioning

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Otitis media with effusion (OME) is a common childhood condition which is characterised by an accumulation of fluid in the middle ear and consequent fluctuating conductive hearing loss. Children with the same audiogram can be differently affected by their hearing loss. There is some debate about the impact of OME on cognitive functioning.

We recently developed the ECLiPS questionnaire (Evaluation of Children’s Listing and Processing Skills; Barry & Moore, 2014). It is a parental report-based measure which supports the assessment of children referred for suspected auditory processing disorder. In this study, we considered the clinical utility of the ECLiPS in supporting assessment of children with OME by considering its sensitivity to i) severity of symptoms of OME, and ii) improvements in hearing abilities subsequent to surgical intervention.

The study included: i) children referred to surgery (GS, n=11), ii) children under active observation (AO, n=9), iii) healthy control children (CC, n=21). Parents completed the questionnaire when OME was diagnosed (time 1) and then 3 months later (time 2) in the AO and CC group, or 3 months after surgery in the GS group. Severity-related differences in parental responses were observed at time 1. The analyses at time 2 further indicated a significant reduction in symptom severity post-surgery in the GS group. The ECLiPS is sensitive to impact on everyday functioning in children with different severities of OME. It may provide clinicians with useful information to supplement the audiogram when assessing the impact of OME on a child’s everyday listening experience.
Theory-of-mind in individuals with Alström syndrome in relation to Executive functions and verbal ability

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This presentation focuses on dual sensory loss in individuals with Alström syndrome (ALMS) and the role of Executive functions (EF) in development of Theory-of-mind, defined as an ability to impute mental states to self and to others. ALMS causes progressive sensorineural hearing loss and juvenile blindness, affecting communication, as well as other organ dysfunctions.

Ten individuals with ALMS, and 20 nondisabled individuals matched for age, gender and educational level participated. Sensory functions were measured. ToM was assessed by Happe’s strange stories, verbal ability by a vocabulary test and EF by tests of updating and inhibition. Information about communicative skills and motor skills were obtained from questionnaire responses.

The ALMS group was outperformed by the nondisabled control group in both the ToM task and the EF task. The ability to update information correlated with verbal ability, whereas inhibition related to the ability to sustain communication, both capacities of importance in ToM development. Poorer performance in specifically inhibition was in turn related to odd rhythm of speech and occurrence of motor mannerisms.

A significant relation was established between ToM and EF in this population, probably reflecting the importance of EF in developing a capacity to perceive and process input from the social environment during challenging circumstances. Limitations in EF might be related to lack of sensory input, but maybe also to cerebellar dysfunction.
Our research focuses on children’s ability to discriminate phonetic contrasts in their native language (French) and lexical-tone contrasts in an unknown language (Thai). A first group of 30 native-French children (4;2 to 6;5 years) was tested in silence. In a consonant task, the syllable /aba/ was repeated, followed either by the syllable /aba/, /ada/ (change in place of articulation) or /apa/ (change in voicing). In a lexical-tone task, the syllable /bá/-rising was repeated, followed either by the syllable /bá/-rising, /bà/-falling or /ba/-flat low pitch (change in pitch contour and pitch level). Children had to press a response button when they perceived a change. Because of ceiling effects, we made the task harder in order to increase children’s attentional level. A second group of 30 native-French children (4;4 to 6;9 years) performed the discrimination tasks in noisy condition. A speech-shaped noise (stationary noise without linguistic information) was used to mask the stimuli at +5dB SNR. Children younger than 5 years did not succeed the task. The oldest got higher performances in the consonant task (native language) than in the lexical-tone task (unknown language). Moreover, results in the consonant task revealed that children were significantly more accurate and faster at discriminating a change in place of articulation than a change in voicing. However in the lexical-tone task, no significant difference was obtained between the 2 change conditions. We will discuss how the speech-shaped noise can affect in a different way the perception of speech in native and non-native languages.
Speech perception in different background noises by aging persons with normal hearing

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With advancing age, people experience speech perception difficulties, especially in adverse listening conditions. The ability to understand speech in noise depends on the temporal and spectral characteristics of the noise. In this study, we examine how speech perception in different background noises is affected by age in persons with normal peripheral hearing and cognition. Testing includes speech identification tasks in three noise types: steady-state and amplitude modulated speech weighted noise, two energetic maskers, and the International Speech Test Signal (ISTS), a distractive, informational masker. The tests are administered to young (20-30 yrs., N=17), middle-aged (50-60 yrs., N=15) and older adults (70-80 yrs., N=10). All participants have normal audiometric thresholds (≤ 25 dB HL, 125 Hz-4 kHz) and are screened for cognitive impairments (≥ 26/30 on the Montreal Cognitive Assessment). This stringent subject selection prevents differences in peripheral hearing and cognition from confounding the results. Our data demonstrate that middle-aged and older adults perform worse than young persons, irrespective of the noise type. The ISTS raises a tremendous deterioration in speech identification from middle-age onto old age. Nevertheless, middle-aged participants outperform the older group. This may be explained by their divergent ability to listen in temporal gaps in the noise. Yet, in contrast to the older group, young and middle-aged participants benefit from the presence of temporal noise gaps. Our results suggest that the ability of listening in noise gaps counteracts the deleterious impact of distractive noises, characterizing conversations in daily life, but that this perceptive skill is affected by age.
The influence of visual information on assessment of sound stimuli for environmental sounds

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Currently research into soundscape is carried out without taking into account the sense of sight. Nevertheless, there is no doubt that at the higher levels of the nervous system all the information coming from the different senses is merged together, integrated and analyzed. The senses interact with each other, thus some information (coming from one sense) can be skipped or ignored in favor of information coming from another sense, leading to completely different reactions or behavior. The aim of this paper is to verify, on the basis of psychophysical experiments, how a human being processes audio-visual information coming from the surrounding environment. A set of different environmental soundscapes and landscapes were recorded with an ambisonic microphone and high-definition video camera. Experiment took place in an anechoic chamber, appropriately adapted to present ambisonic recordings with a set up of 25+1 speakers arranged in a cubic form, and also a large screen for video presentation. Experiment was divided into three parts, namely: auditory, visual, and audio-visual. In each part of the experiment ICBEN scale (0-10) was used to rate presented stimuli. In the first part only audio stimuli were presented and subjects were asked to rate the sound annoyance. In the second part of experiment, participants were asked to rate the pleasantness of the presented landscapes. Finally, in the last part of the experiment participants were presented with compatible and incompatible mix of audio and visual stimuli and asked to rate the annoyance.
Relations between real versus ITD-only spatial release from masking and working memory

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Previous studies have found relations between spatial release from masking (SRM) and cognitive ability. Also, the contributions to SRM from interaural time (ITD) and level (ILD) differences has been studied.

In the present study 19 HI subjects (age: 55-84) participated. Speech reception thresholds (SRTs) were determined with a female target talker from the DAT corpus. The maskers were either two different female talkers from the DAT corpus or speech-shaped noise (SSN). Target and maskers were presented over head-phones and lateralized to ±90° using only interaural time differences (ITD). The maskers were either presented co-located or separated from the target. SRTs were lower in the separated trials than in the co-located trials, indicating an ITD-only SRM. Furthermore the DAT masker led to higher SRTs than the SSN masker, probably due to added informational masking.

Working memory was also tested with the reading span test. The poster will examine the relations between ITD-only SRM and working memory, and compare the results to those from previous studies done with real spatial separation (both ITD and ILD).
Hearing impairment is associated with executive components of working memory

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Older people are known to apply cognitive functions to compensate for their impaired hearing abilities. Especially working memory (WM) and attentional functions contribute to speech recognition in noise. According to the model of Baddeley and Hitch, WM consists of a central executive component and storage systems (buffers) for verbal, non-verbal and episodic information. The aim of the present study was to identify the components of verbal WM that are affected in older people with hearing impairment.

Groups of older normal-hearing (NH; N = 15) and hearing-impaired (HI; N = 17) individuals performed different standardized neuropsychological tests of verbal WM, visual attention and cognitive flexibility. The audiological examination of speech recognition included listening situations of different complexity. The HI group achieved significantly poorer performance in tests of WM compared to the NH group (Digit Span sequential, DSs: p < 0.03; Reading Span test, RS: p < 0.01). For all participants, RS performance correlated significantly with the phonological (DSf), executive (DSs and Trail-Making-Test-B) and speed components (Trail-Making-Test-A) of cognitive function as well as speech recognition. These results are consistent with the view that the RS activates several cognitive functions like working memory and executive functions. In general, it is assumed that this is true for listening to speech in noise as well. The high correlation between RS and speech recognition in noise observed here and elsewhere may therefore represent the activation of a wide range of cognitive functions or cognitive (over)load, at least for elderly HI listeners.
Changes in own-voice perception after a hearing aid fitting is one of the top ten most problematic issues reported by hearing aid users. With the development of open-fitted hearing aids, the own-voice distortion caused by the occlusion effect has been reduced for a large proportion of hearing aid users. However, many hearing aid users are still experiencing problems with the own voice, caused by both the occlusion effect as well as unknown factors. In this study, we investigate own-voice issues in naïve and experienced hearing aid users, matched by gender, age, hearing aid types (open fitting, monaural; open fitting, binaural; ear-mold insert, monaural; ear-mold insert, binaural) and hearing losses (PTAs), as well as a control group matched by age and gender. We will present results from ear canal measurements for both air- and bone conducted stimuli, as well as the own voice as a source signal. The subjects' own opinion of their voice, measured through self-reporting questionnaires and controlled listening evaluations, will be discussed in correlation to the results of the audiometric measurements. The listening evaluation consists of a rating of the own voice (generated during live speech and played back through a speaker) and the voices of people known and unknown to the participants. The audiometric tests and listening evaluation are repeated for both aided and unaided conditions, which allows for both objective and subjective indications of how own-voice sounds are processed by a hearing aid compared to the unaided ear.
Evaluation of the Swedish HINT in normal-hearing children aged 6–11 years

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Background: A Swedish version of the Hearing in Noise Test (HINT) has earlier been developed to assess the ability to recognize speech in noise in adults. Objective: The aim is to evaluate the possibilities of using the Swedish HINT speech audiometry sentence materials on children or do we need to do any changes and to investigate whether there is a link between speech in noise results and age in normal-hearing children aged six to eleven years. Study Sample: 111 (59 boys, 52 girls) native Swedish-speaking children aged 6–11, divided into three groups. Design: Signal to noise ratios (SNRs) for 50 \% correctly repeated sentences were measured to establish mean performances across three age groups, and child performance were compared with adult performance to validate the normalization protocol for the Swedish HINT. Results: SNRs decreased with age and in children older than 8 yrs approached adult values. No significant learning effect was found. Conclusions: It is possible to use the HINT for normal-hearing children from six years of age. The findings concur with the literature on age effects in auditory processing abilities, showing increases with age and with a larger variability in lower ages.
Acclimatization and training benefit in severely hearing impaired adult listeners using frequency compression

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Over the years, a number of studies have shown that frequency lowering of the hearing aid signal results in speech intelligibility improvement for only some of the hearing impaired listeners. More recent studies investigated different factors that would explain individual differences in benefiting from such signal processing methods albeit without reaching a firm consensus. One such factor is the role of acclimatization to frequency lowering. There are also indications that one aspect of working memory may be linked with sensitivities to the distortions present in the frequency compressed signal. The aim of this study was to investigate the influence of acclimatization and training on the frequency compression benefit in adult listeners. We were also interested in assessing the role of two individual factors in the overall benefit from acclimatization and training with frequency compression. Thirty-nine severely hearing impaired adult listeners participated in the study. All listeners underwent two weeks of home trials while wearing non-linear frequency compression (NLFC). Additionally, a subset of listeners took part in a computer-based audio-visual phoneme discrimination training program. Outcome measures comprising speech in quiet, nonsense syllables and sentences in noise were used to assess the performance of all participants before and after the two week acclimatization period. The individual factors investigated were age and working memory capacity (measured with the reading span test). Preliminary results point towards the age being a better predictor of the NLFC benefit than the working memory capacity. Acclimatization and training resulted in different benefits for different outcome measures.
In recent years, more and more attention is being given to understanding the cognitive aspects of speech comprehension in hearing-impaired individuals. This is partly motivated by reports of the mental fatigue experienced by hard-of-hearing persons despite achieving high speech intelligibility scores with their hearing devices.

According to the framework of “levels of processing”, processing depth increases as a given verbal task moves from phonological recognition to semantic extraction. Deeper levels of processing require more cognitive resources and are therefore more susceptible to the effects of degraded signals or competing tasks, that is, more “listening effort”. Among the many proposed measurement methods, behavioural paradigms excel in being more clinically feasible than electrophysiological techniques while not relying on subjective reports from the patients themselves.

The goal of the present study is to develop a sensitive and reliable dual-task assessment of listening effort for children aged 8 to 12. The test takes into account interests, cognitive abilities, and semantic knowledge of this particular population. In addition to repeating words, a child will be instructed to react quickly to one of the following three conditions: seeing an even number (a visual categorization task), hearing an “animal” word (an auditory categorization task), or hearing a “dangerous” word (a more elaborate auditory categorization task). An increase in reaction time will indicate an increase in cognitive demands imposed by the experimental procedures. After pilot testing, this behavioural paradigm will be validated in normal-hearing school-age children. The data from the study will be presented at the conference.
The aim of the study was to examine the relationship between working memory capacity (WMC), executive functions (EFs) and perceived effort (PE) after completing a work-related task in quiet and in noise in employees with aided hearing impairment (HI) and normal hearing. The study sample consisted of 20 hearing impaired and 20 normally hearing participants. Measures of hearing ability, WMC and EFs were tested prior to performing a work-related task in quiet and in simulated traffic noise. PE of the work-related task was also measured. Analysis of variance (ANOVA) was used to analyse within and between-group differences in cognitive skills, performance on the work-related task and PE. The presence of noise yielded a significantly higher PE for both groups. However, no significant group differences were observed in WMC, EFs, PE and performance in the work-related task. Interestingly, significant negative correlations were only found between PE in the noise condition and the ability to update information for both groups. In summary, noise generates a significantly higher PE and brings explicit processing capacity into play, irrespective of hearing. This suggest that increased PE involves other factors such as type of task that is to be performed, performance in the cognitive skill required solving the task at hand and whether noise is present. We therefore suggest that special consideration in hearing care should be made to the individual’s prerequisites on these factors in the labour market.
Student’s second-language grade may depend on classroom listening position

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This experiment explored whether position, close to or at a distance from the sound source, in the classroom, and the reverberation time in the classroom, influenced Swedish speaking participants’ score on a test for second-language (English) listening comprehension. The listening comprehension test administered was part of a standardized national test of English used in the Swedish school system. A total of 133 upper school pupils, 15 years old, participated. Listening position was manipulated within subjects and classroom reverberation time was varied between subjects. The results showed that English listening comprehension decreased with the distance from the sound source. Participants with higher proficiency scores for English were less susceptible to this effect. Classroom reverberation time had no significant main effect and it did not interact with listening position. The results indicate that listening comprehension scores — and hence students’ grade in English — may depend on their classroom listening position.
In a recent study (Rönnberg, Hygge, Keidser & Rudner, 2014) we reported cross-sectional epidemiological data from the UK Biobank, which in total contains >500,000 individuals in the UK. The focus in that study was on the effects of functional hearing loss and age on long- and short-term visuospatial memory. Our selection of variables resulted in a sub-sample of 138,098 participants after discarding extreme values.

A digit triplets functional hearing test was used to divide the participants into three groups: poor, insufficient and normal hearers. We found negative relationships between functional hearing loss and both visuospatial working memory (i.e., a card pair matching task) and visuospatial, episodic long-term memory (i.e., a prospective memory task), with the strongest association for episodic long-term memory. The use of hearing aids showed a small positive effect for working memory performance for the poor hearers, but did not have any influence on episodic long-term memory. Age also showed strong main effects for both memory tasks and interacted with gender and education for the long-term memory task.

Close to 20,000 of the original (>500,000) participants recently went through the very same test battery a second time, 2-7 years after the first time. In the present study, we will scrutinize in which respects the addition of extra years in the longitudinal analysis is commensurable with extra years from our previous cross-sectional analysis, for the same sets of original moderators and mediators.
Characterizing performance in an auditory dual task for listeners with normal hearing and simulated hearing loss

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In realistic listening environments, there is often a competing demand for auditory attention, so that listeners might be required to monitor critical auditory events around them, while simultaneously attending to an ongoing auditory signal. Despite several decades of research on auditory attention, it is still not fully understood how performance in such tasks can be best characterized or how hearing impaired listeners perform in such tasks. The goal of the current experiment was to assess and characterize task-dependent costs while listeners were required to process two auditory stimuli. Ten normal-hearing or simulated hearing loss listeners identified an ongoing stream of color/number keywords originating at 0° azimuth (primary signal), while detecting the presence of a critical call sign originating from locations ranging from -45° to +45° (secondary signal) when these two signals were presented either simultaneously or sequentially. The difficulty of the primary task was varied by requiring stimuli identification in an auditory one- or two-back memory recall task. The difficulty of the secondary task was varied by increasing the set-size of critical call signs that listeners had to monitor. Preliminary results indicate that a listener’s ability to perform the secondary task increased as its spatial location moved further away from 0° azimuth and performance was modulated minimally by the difficulty of the primary task. Performing these two tasks simultaneously resulted in a significant reduction in performance in both tasks, compared to the sequential condition. Not surprisingly, simulated hearing loss resulted in a further degradation of performance. The result has important implications for hearing impairment in complex, multitalker environments.
Selective spatial attention in a two-stream auditory steady-state paradigm

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Many people report difficulties in understanding speech in background noise. One possible reason may be a reduced ability in separating the acoustic information into discrete streams based on their location in space. The reduced ability in benefitting from a spatial separation between speech and noise is not fully accounted for by pure tone hearing thresholds, which suggests the involvement of additional central mechanisms. A two-spatial-stream auditory steady-state response (ASSR) paradigm was developed to monitor the neural correlates of auditory spatial attention. In particular, it was investigated whether auditory selective attention effects as reflected in the ASSR amplitude can be confirmed at low modulation rates relevant for speech processing (4 and 7 Hz). High-density EEG data were recorded from N=28 participants attending to one of two continuous sounds concurrently played from different speakers. Offline, EEG data were spatially high-pass filtered (current source density) and point-biserial correlation analysis was used to identify the spatial signature of the attention effect. Across all conditions, ASSR analysis revealed a significant attention effect (<.001), demonstrating a 1.2 dB increase in power for attended compared to unattended streams. Interestingly, individual differences in the benefit of the spatial separation of speech and noise, as measured with the Intelligibility level difference (ILD) of the OLSA, correlated with the EEG attention effect such that individuals with stronger neural attention effects had larger ILD benefit. The implications for hearing impaired individuals and development of an auditory neurofeedback system will be discussed.
Relations between visual and auditory lexical decision and speech recognition of cochlear implant users and normal hearing listeners

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In previous studies we found that lexical access (measured visually with two tests) is a predictor of speech recognition in noise performance in normal hearing listeners with varying levels of proficiency in Dutch. In Cochlear Implant (CI) users a similar relation between lexical access and speech recognition was found, although, as expected, auditory factors were the main predictor of CI results.

The current study focuses on visual and auditory lexical decision and the relations of these tests with speech recognition for individuals with normal hearing and for CI-users. More insight in these relations might help understanding speech recognition performance of individual patients and be helpful in designing individual rehabilitation programs.

The study population consists of twenty-two post-lingually deaf CI users and a group of normal hearing listeners. For the latter also conditions with simulated hearing loss were included. Lexical access was measured with a visual (vLDT) as well as an auditory lexical decision test (aLDT) and a simple word naming test. In addition, speech recognition scores were measured for CVCs and for digit-triplets and short meaningful sentences in steady-state noise.

Results for the CI-users show normal vLDT scores. However, for the aLTD the performance is reduced and the test parameters (RTs for word vs pseudo-words) show different patterns. These findings will be related to normal hearing performance in conditions with simulated hearing loss to analyse the interplay between impaired peripheral processing, lexical representation and speech recognition performance.
The relationship between functional hearing and verbal reasoning

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Verbal reasoning performance is an indicator of the ability to think constructively in everyday life, and relies particularly on semantic long-term memory and working memory. Using cross-sectional data from the UK Biobank resource, obtained on over 100,000 40-70 year olds, this study investigated the effect of functional hearing on numerical and linguistic verbal reasoning when controlling for age, gender, and education. The study further investigated if hearing aid usage mitigated the effect, and examined different pathways from hearing to verbal reasoning. Multiple regression analyses showed that poor functional hearing was significantly associated with reduced numerical and linguistic verbal reasoning scores, and that hearing aid usage mitigated the association among those with poor hearing. Hearing significantly interacted with education as larger negative effects of hearing were seen among those with higher levels of qualifications. Structural equation modelling showed that education partially confounded, and the central executive function completely mediated the association between hearing and verbal reasoning when controlling for age. The mediation effect by the central executive function was further partially confounded by computer usage. Findings encourage further investigations into a possible positive effect of hearing aid usage on verbal reasoning (and other cognitive tasks) and of multi-tasking computer games on the central executive function/working memory in middle-aged hearing-impaired adults.
How many measures of aided speech-recognition performance are needed to document outcomes for older adults?

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This study was undertaken to examine how many measures of speech-recognition are needed when documenting benefit from intervention. Often researchers obtain multiple speech-recognition measures for different acoustical conditions or different speech stimuli. We have often observed moderate to strong correlations across all such measures obtained from groups of older adults. Here, we examined this further in 59 older adults (61-79 y) with mild to moderately-severe sensorineural hearing loss. Each subject completed six measures of open-set speech recognition which made use of words, phrases, or sentences in speech-like noise and two-talker babble. Stimuli were delivered monaurally via an insert earphone and spectrally shaped based on each participant’s pure tone thresholds, targeting restored audibility of the speech spectrum through at least 4000 Hz. All six measures of speech recognition were moderately-to-strongly and significantly (p < .01) correlated. Subsequent factor analysis yielded a single factor accounting for 71% of the variance. Clearly, six measures of speech recognition were unnecessary given the redundancy among the measures identified in the factor analysis. Subsequent correlations and regression analyses indicated that the individual differences in aided speech-recognition performance were mainly attributable to differences in high-frequency hearing loss (37% of variance), with slight additional effects of age (an additional 4% of variance) and no effects of executive function.
Performance, proficiency and perceived disturbance in native and non-native languages

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Identifying speech in adverse listening conditions requires both native and non-native listeners to cope with decreased intelligibility. The current study examined in four speech reception threshold (SRT) conditions how speech maskers (two-talker babble Swedish, two-talker babble English) and noise maskers (stationary and fluctuating noise) interfered with target speech in Swedish (native language) and English (non-native language). Listening disturbance for each condition was rated on a continuous scale. The participants also performed standardized tests in English proficiency, nonverbal reasoning and working memory capacity; the latter in both Swedish and English. Normal-hearing (n = 23) and hearing-impaired (n = 23) native Swedish listeners participated, age-range between 28 and 65 years. The SRTs were better for native as compared to non-native speech. In both groups, speech perception performance was lower for the speech than the noise maskers, especially for non-native target speech. The level of English proficiency is important for non-native speech intelligibility in noise. A three-way interaction effect on the subjective rating scores indicated that the hearing loss affects the subjective disturbance of Swedish babble in native and non-native language perception.

Conclusion: Speech perception and subjective disturbance is influenced by a complex interaction between masker types and individual abilities.
This study investigates whether changes over the adult life span and changes in hearing status influence articulation precision of sibilant fricatives ([s] as in Sue and [ʃ] as in shoe) in a normative adult sample and in postlingually deafened novice cochlear implantees. As reduced (and restored) auditory feedback may gradually impact on feedforward commands for speech production, we investigate whether articulatory precision, as indexed by spectral mean for [s] and [ʃ], is modulated by hearing loss. Furthermore, we investigate whether advanced adult age may impact on articulatory precision beyond effects of hearing. Participants were asked to read aloud a carrier sentence containing target words starting with either sibilant. Our analyses for the normative group (n=107, younger, middle-aged and older Dutch adults with normal hearing to mild hearing loss) show that high-frequency hearing loss, but not age per se, predicted the spectral mean of the [s] (but not [ʃ]) productions, with lower spectral means for those with higher pure-tone hearing thresholds. Thus, even relatively subtle hearing loss reduces the distinctiveness of this consonant contrast. In the second part of our study we investigate sibilant production precision of CI patients (N ≈ 10) relative to the normative data. Their sibilant production is tested prior to implantation, and at two follow-up examinations (2 and 12 weeks after implantation). CI patients’ production performance and improvement will be related to their (aided) speech audiometry results (before and after implantation) and the duration of their hearing loss. Results of this second part will be discussed.
Speech intelligibility of early implanted adolescents with a cochlear implant in class-like listening situations

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Introduction and aim: Recent results (Cora, 2014) show that as many as 77% of the prelingually deafened early implanted children are enrolled in secondary mainstream school. The class challenges are numerous, e.g. poor room acoustics, big group sizes, less visual support and group discussions. To have a realistic estimate of the speech perception of implanted children in a classroom setting, we aimed at creating a reliable and feasible speech test that captures these challenges.

Material and method: A complex speech test was developed consisting of different sound sources, mimicking the position of different students in class, and a varying babble noise field, simulating the babbling of students in an occupied classroom. Easy Dutch sentences were presented from 4 speakers while the intensity of the noise varied automatically. Via this adaptive method an average signal to noise ratio could be obtained at which 50% of the speech is understood (SNR-SRT). A pilot study was carried out on 10 normal hearing (NH) adolescents to determine the feasibility of the test. To assess the reliability, the SNR-SRT was measured on two moments in time in order to calculate an interclass correlation coefficient (ICC).

Results: Test-retest reliability was calculated and mean values were obtained for 10 NH adolescents which will allow further comparison in adolescents with a CI.

Conclusion: The complex speech test mimicking a realistic classroom situation (e.g. group discussion) is feasible for clinical use. The favorable test-retest reliability shows that the adaptive method is a reliable method to obtain an average SNR-SRT.
Presbycusis and Dementia: 
A Literature Review of Underlying Factors

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Presbycusis (age-related hearing loss) is a highly prevalent condition with an estimated 30% of adults over 65 experiencing moderate-to-severe hearing loss. Longitudinal research has established that presbycusis is linearly associated with increased rate of cognitive decline and dementia. However, the mechanisms underpinning this relationship are unclear. Presbycusis may represent a modifiable risk factor or marker for dementia. The purpose of this review is to investigate the literature for potential factors that may explain this relationship. PubMed, Cochrane Library, and Clinical Trials were searched for published papers of observational, experimental and review studies, supplemented by manual searches of bibliographies of key articles.

The literature outlines several potential factors. Common cause factors include; cellular oxidative stress and impairment of homocysteine metabolism in the brain and cochlea through poor nutrition or diet; APOE-e4, a genetic risk factor linked with an increased risk of both Alzheimer’s disease and presbycusis; and vascular factors such as diabetes and hypertension, possibly due to deterioration in microvascular structures in the brain and cochlea. Presbycusis may lead to greater vulnerability to dementia neuropathology through; loss of stimulation as presbycusis causes neurological deterioration in the medial temporal lobe and decreased whole brain volume; and neural compensation to cope with this neurological deterioration and loss of hearing function leading to less reserve to cope with dementia neuropathology.

The relationship between presbycusis and dementia is mostly likely multifactorial. Further research is needed to determine which factors are most dominant as this will have implications for future research and development of therapies.
Auditory processing and language in children with mild to moderate sensorineural hearing loss: A follow up program of research

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Severe or profound hearing losses often result in delayed language development, but recent research shows that even a mild to moderate sensorineural hearing loss (MMSNHL) can contribute significantly to language problems. For a child with residual hearing, the compensation for auditory losses both behaviourally (e.g. lip reading) and cognitively is critical to their future language development and basic auditory processes that govern spectral and temporal processing of auditory signals are thought to be of considerable importance for future language development in children with MMSNHL. In a previous study conducted at our lab, Halliday, Tuomainen and Rosen (under review) assessed the auditory processing (frequency modulation detection, frequency discrimination, etc.) and core language skills (vocabulary, reading, grammar) of 8-16 year-olds with MMSNHL and age-matched peers with normal hearing. Results suggested a significant relationship between performance on auditory processing tasks and language assessments. These results may encourage the hypothesis that training auditory processes might lead to improved language development, but more research is needed before such an intervention can be developed. The present experiment hopes to replicate Halliday, Tuomainen and Rosen’s findings in a new, younger group of children with MMSNHL, and to explore the effect of other cognitive functions and auditory processing on language outcomes. The test battery includes the same language and auditory processing tests used by Halliday and colleagues, as well as additional tests of executive function (e.g. auditory attention and memory). Preliminary results will be reported at the conference.
Speech is characterized by slow variations in sound energy. The temporal pattern contained in these slow sound amplitude modulations allows us to perceive the speech rhythm and syllable structure. Recent research suggests that accurate detection of sound amplitude modulations are important for the development of phonological awareness in children – a mechanism that may be impaired in developmental dyslexia. How rhythmical sound amplitude modulations, such as the speech contour (envelope), is encoded in the brain is not known. Here, we use the mouse as a model for studying the neural mechanisms underlying the basic processing of sound envelope cues on the brainstem level. By investigating cellular filtering properties with the patch-clamp technique and mathematical modelling in a group of brainstem neurons that receive highly temporally preserved monaural inhibitory inputs, it was discovered that subtle variation in ion channel composition determines the tuning of these neurons to temporally modulated inputs. Thus, converting the sign of the incoming spike code to inhibition, which activates hyperpolarization-activated ion channels, these cells are predicted to extract and encode the slow temporal sound structure specific for vocalization patterns, such as sharp sounds edges, stressed syllables and the syllable rate. It is speculated that these auditory feature-detection neurons are involved in the bottom-up processing of linguistic information correlated to the perception of prosody in humans.
Do top-down processes influence involuntary attention in the elderly?

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The efficient processing of target sounds in an environment that consists of targets and non-targets requires that irrelevant non-target sounds be ignored. Irrelevant sounds can however interfere with task performance because they involuntarily capture attention (auditory distraction). In younger adults, such interference can be reduced by top-down executive control (paying extra attention). The extent to which elderly adults can employ such mechanism is not yet known. To answer this, elderly and young adults performed either a simple visual classification task or an n-back working memory version, during which they heard either standard tones (600-Hz) or various novel environmental sounds. Event-related potentials were recorded and the auditory distraction caused by novel sounds was compared for young and elderly as a function of the visual classification task performed. Preliminary results show that: 1. The distractor sounds in the higher cognitive load visual task (n-back) led to slower reaction times and higher error-rates in the elderly; 2. The elderly exhibited a larger attenuation of the P3a response (a neural indicator of auditory distraction) than young adults; 3. The MMN (an index of change detection) was also greater in the elderly. These results suggest, the elderly pay more attention to the difficult n-back task than young adults and this greater allocation of resources to the task results in a weaker response to the distracting sound (hence a smaller distraction effect at the neural level). Furthermore, this concentration of resources to guard against distraction may compromise response execution, leading to slower, more erroneous responses.
The effects of complementing an educational program for hearing aid users with Internet support: A randomized, controlled trial implemented in a General Clinical Practice

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Audiologic rehabilitation aims to improve communication for people with hearing impairment. Education is widely regarded as an integral part of rehabilitation, but the effect of the delivery method of an educational program on the experience of hearing problems has rarely been investigated in controlled trials. Internet as a complement to audiological rehabilitation has been tested in different studies with promising results. Though, until now not applied clinically as a part of an audiological rehabilitation, focused on hearing aid users with persistent self-reported activity limitation and participation restriction.

The purpose of this study was to examine the short- and long-term effects of complementing an educational program for hearing aid users with Internet support. 74 hearing aid users were randomly assigned to an intervention group or a control group. The intervention group had access to a book about hearing and hearing loss and the Swedish version of Active Communication Education; ACE. The intervention group received weekly home training assignments; which were discussed with the audiologist by telephone at the end of each treatment week. The intervention group also attended a discussion forum at the trial website; without any interaction with the audiologist. The control group only had access to parts of the book and was asked to read and evaluate the content.

The Hearing Handicap Inventory for the Elderly, the Hospital Anxiety and Depression Scale, the International Outcome Inventory for Hearing Aids and the Communication Strategies Scale were used to measure the outcomes of this study. The results will be presented.
The impact of open learning space in primary school classrooms on the cognitive load of children in Australia

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The primary school environment is of paramount importance in the development of a child. One of the recent trends is to go away from the traditional “Chalk and Talk” classroom configuration towards “Agile Learning Spaces” where children, seated in small groups, have to constantly separate the speech signals from their peers and teachers in the same group from the competing background noise generated by other groups.

The aim of this project was to assess the effect of the sound environment of these new learning spaces on the students’ ability to understand speech in noise and on their learning abilities. A dual task paradigm was used to collect data from 17 normally hearing children aged 7-12 years. Participants repeated AB words presented in babble noise (primary task) at different classroom signal to noise ratios (SNR: quiet, +4dB, 0dB, -4dB), while simultaneously memorizing a set of five digits to be recalled later (secondary task). The school sound environment was reproduced in a sound proof booth with a circle of 12 loudspeakers. Results of the single task conditions showed that, at 4 dB SNR, children can perceive on average 81% of the words accurately and can remember 85% of the digits. In the dual task condition, only performance of the secondary task decreased significantly. Surprisingly, no effect of SNR was observed. This study showed the importance of considering the effect of noise on the children ability to learn and to understand the teacher in their new learning environment.
Individuals with hearing loss commonly report feelings of fatigue and stress as a result of the mental demands of listening (McGarrigle et al., 2014). In this talk we present the results of two experiments where we measured these mental demands (i.e., ‘listening effort’) objectively, using pupillometry. Pupil dilation has been shown to reflect the mental effort required to understand speech in challenging listening environments (Zekveld et al., 2010). Conversely, pupil constriction has been shown to reflect subjective fatigue (e.g., from sleep deprivation) (Morad et al., 2000).

In Experiment 1, we attempted to replicate the task-evoked listening effort effect during a speech recognition task in multi-talker babble noise with varying signal-to-noise ratios. In Experiment 2, we investigated: (i) whether pupil size was sensitive to changes in listening effort in a more naturalistic listening task, and (ii) whether pupil size following a period of effortful listening can also reflect listening-related fatigue. We discuss the importance of using naturalistic listening tasks in the measurement of listening effort and fatigue, as well as understanding the nature of the relationship between these constructs.
The challenges faced by people with hearing loss when listening to speech, particularly in noise, demands effort, which results in self-reported tiredness ranging from fatigue to exhaustion. Although clinical speech perception tests are used to verify hearing ability, they lack sensitivity and do not consider the role of ‘listening effort’ in the client’s everyday life. Understanding what listening effort is, and the cognitive processes that underlie it, is in the early, yet promising, stages of inquiry. Previous objective studies with normal hearing participants indicate that more demanding listening conditions lead to an increase in pupil dilation, and greater activity in the alpha oscillatory network. Additionally, increased power in the alpha network has been linked to various cognitive tasks, namely working memory and attention.

The current study examines the effect of speech degradation on both pupil and alpha oscillations in 10 normal hearing, monolingual adults (18-35 years of age) during a standard clinical speech perception test. Preliminary results suggest that varying levels of speech degradation, using channel vocoding and 4 talker babble noise, can elicit changes in pupil size and alpha power (as shown in the parietal region), and that these objective measures are associated with performance outcomes and cognitive ability. The findings of this study may have important implications for the re/habilitation outcomes of people with hearing loss.
Auditory verbal working memory capacity
as a predictor of speech masking release:
Normal-hearing and hearing-impaired listeners

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Background noise can interfere with, or mask, our ability to understand speech. When temporal fluctuations are imposed on steady-state noise maskers, normal-hearing listeners may benefit more than hearing-impaired listeners with a sensorineural hearing loss (SNHL) from speech masking release, i.e. the ability to “listen in the dips” of modulated noise maskers. Factors beyond reduced audibility in SNHL listeners, including both perceptual and cognitive mechanisms, contribute towards the ability to benefit from speech masking release. It is well established that working memory capacity influences the ability to understand speech presented in noisy backgrounds. Here we assessed the relationship between speech masking release and auditory verbal working memory (AVWM) capacity in both NH and SNHL listeners. In contrast to previous work, AVWM was assessed using several standardized tests of AVWM (digit recall, backwards digit recall and non-word repetition) to isolate the cognitive resources required to benefit from speech masking release. After controlling for the effects of age and average pure-tone hearing threshold, digit recall and non-word repetition scores predicted speech masking release in SNHL listeners but not NH listeners. Therefore SNHL listeners may rely more on cognitive resources, including both short-term and phonological working memory, to aid speech masking release. These results demonstrate a specific role for AVWM in the established link between working memory capacity and the ability of SNHL listeners to understand speech in noisy backgrounds: AVWM may support speech masking release through the retention of transient glimpses of “meaningless” speech for delayed reassembly and interpretation.
Attended speech reconstruction from EEG: towards the online, every day application

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Recent studies have shown that temporal envelope based speech reconstruction from electroencephalography (EEG) and magnetoencephalography recordings can be used to identify the attended speaker among multitude of other speech streams. Our long-term goal is to transfer this method to an online scenario suitable for daily life applications, relying on robust and low channel EEG technology. Consequently, the present work replicated a previous study (O’Sullivan et al., 2014, Cerebral Cortex) and explored the necessary technical requirements for practical attended speech decoding with EEG. Twelve normal hearing participants attended to one out of two concurrent speech streams, while high-density EEG was recorded. Offline data revealed results closely corresponding to those reported by O’Sullivan et al. Subsequently, iterative channel elimination was performed based on the individual channel contribution to the decoding process. This procedure provided insight into the minimum number of channels necessary for decoding and their individualized, optimal layout, and also revealed the optimal cross-subject channel configuration. On average, decoding accuracy was stable from 96 channels down to 25. Moreover, aiming towards near real-time decoding, the performance of the individually trained decoder was assessed and the minimum duration of training data necessary for successful classification was determined using a chronological cross-validation approach. For less than 15 min of training data, a subject-independent (pre-trained) decoder revealed better performance than an individually trained decoder. These findings help bridge a gap between high-density laboratory studies and efficient every day speech decoding.
Online administration of a speech in noise test
and its relationship to cognition, hearing
problems and mental health

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Hearing loss is common, but often both undetected and untreated. In this two-
part study we evaluated an online hearing test and used this test to explore po-
tential links between hearing status, cognitive abilities, psychological distress as
well as quality of life.

Out of a total of 1370 online recruited participants who completed the procedu-
re, 16.2% failed the online hearing test. Hearing difficulties were more prevalent
among the older participants. Poor self-rated hearing ability, as measured by the
Amsterdam Inventory of Auditory Handicap, increased the odds ratio for failing
the hearing test (OR 2.34, 95 % CI 1.74-3.15). The same was true for scoring above
the cut-off score of 11 on the anxiety subscale on the Hospital Anxiety and Depres-
sion Scale (OR 2.55, 95 % CI 1.22-5.33). On the other hand, good performance on
the cognitive tasks lowered the risk for a failed hearing test.

We conclude that online hearing tests may have the potential to reduce the time
lag between noticing hearing difficulties and beginning a process to address the
problem. Moreover, online data collection facilitate large scale investigations on
the links between hearing, cognition and perceived communication and mental
health problems.
Greater explicit cognitive resources support speech-in-noise identification in elderly normal-hearing listeners

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Prior studies have demonstrated that cognitive capacity of listeners is a key factor in speech-in-noise tests in young-normal-hearing listeners (e.g., Moradi et al., 2014) and hearing-impaired individuals (e.g., Foo et al., 2007; Rudner et al., 2012). In addition, aging is associated with decline in sensory and cognitive functions that may impair speech perception in noisy conditions.

The present study aimed to investigate the relationships between working memory and attentional capacities and speech-in-noise identification in elderly normal-hearing listeners. Twenty-four native Swedish speakers (13 women and 11 men) normal hearing were recruited to participate in the study. The mean age of participants was 71.5 years (SD = 3.1 years, range: 66–77 years). The reading span test (RST) and the Paced Auditory Serial Attention Test (PASAT) were used to measure working memory capacity and attentional capacity, respectively. The speech-in-noise identification measured using the HINT (at 50% correct level) and Hagerman test (at 80% correct level). Results showed that individuals with greater working memory and attentional capacities had better performance in HINT and Hagerman tests. These findings support the notion that explicit cognitive resources of listeners play a critical role in identification of speech stimuli under degraded listening conditions.
Comparison of gated audiovisual speech perception between elderly hearing-aid users and elderly normal-hearing listeners

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The addition of visual cues to amplified auditory signals by hearing aids resulted in better identification of speech stimuli relative to unaided audiovisual or aided auditory-only conditions (Walden et al., 2001). An important question that remains unexplored is whether hearing-aid users have the same level of ability for audiovisual speech perception relative to their age-matched normal hearing counterparts.

Here we present the preliminary findings from collected data of 18 elderly hearing-aid users and 18 normal-hearing listeners in gated-audiovisual identification of different types of speech stimuli (consonants, words, and final words in low-predictable and high-predictable sentences). In terms of isolation point (IP; the shortest time from the onset of an speech stimulus required for correct identification of that speech stimulus), results showed that elderly hearing-aid users needed more IPs for identification of consonants and words than elderly normal-hearing individuals under quiet condition. There were no differences between two groups in IPs needed for identification of final words embedded in low-predictable or high-predictable sentences. In terms of accuracy, both elderly hearing-aid and elderly normal-hearing groups achieved ceiling on audiovisual identification of speech stimuli under quiet condition.
Impaired speech perception occurs in several groups of children enrolled at Speech Language Pathology and Audiological clinics. These may be children with language impairment, attentional difficulties, hearing impairment and central auditory processing disorders. At present, no standardized speech perception test in Swedish provides information about how children discriminate, identify and produce consonantal contrasts in words. It is therefore of great importance to develop diagnostic tools to obtain a reliable test procedure and enable differential diagnostics. The present study had two purposes; to prepare and standardize a new speech perception test, the Listen-Say test with the use of minimal word pairs, and to investigate how normally hearing children perform in quiet and in 4-talker babble. The study included 27 children aged 6-9 years. Consonant contrasts were divided into seven wordlists. Results showed that the children discriminated significantly more correct consonantal contrasts in quiet (92%) compared to 4T-babble (88%) for all consonant contrasts combined. The significant effect of 4T-babble was evident for dental-velars, voiced-voiceless, and syllable complexity. Further, in 4T-babbel, significantly shorter reaction times for correct identification of target words were observed, i.e. in the speech background, children responded in a more superficial way. Overall, the lowest accuracy scores were observed on voiceless fricatives. Before clinical use, further normative data will be collected. In addition, the sensitivity of the wordlists to various clinical groups will be assessed. Nevertheless, the first data collection with the Listen-Say test indicate that the test appear to be sensitive for predicted perceptual difficulties of different consonantal contrasts.
Statistical learning plays a key role in language processing, e.g., in adaptation to novel listening conditions, such as spectrally degraded speech. Older adults have been reported to show less statistical learning on the basis of visual input than younger adults. Given the importance of statistical learning for speech processing, we investigated whether statistical learning is also decreased in the auditory modality in older compared to younger adults and whether hearing acuity is associated with individual learning ability.

Thirty younger and thirty older adults performed an auditory artificial-grammar-learning task to assess statistical learning ability. Participants saw a visual display of four nonwords. They then had to click as fast as possible on those nonwords that were presented auditorily. Within each trial, two nonwords were presented, the second nonword being predictable on the basis of the first. Once participants detected the regularities in the nonword combinations, they started anticipating the second target and thus got faster in their click response.

In younger adults, perceptual effort due to poorer hearing came at the cost of processing resources required for learning. Overall however, younger and older adults showed equal amounts of auditory learning, suggesting that the general ability of statistical learning is preserved over the adult life span. Additionally, we will discuss results of follow-up experiments in which we determined that differential age effects on visual and auditory statistical learning should indeed be attributed to modality and not to other confounding differences (such as linguistic vs. shape items, and the way items are cued).
In our previous study (Ng et al., 2013), a group of experienced hearing aid users performed a free recall test (Sentence-final Word Identification and Recall test; SWIR). High performers on the test reported more residual difficulty with hearing aids in challenging listening situations. In the present study, we continued to explore relations between recall performance using a modified SWIR test that was less cognitively demanding (Ng et al., 2015) and self-reported hearing aid outcome. The International Outcome Inventory – Hearing Aids (IOI-HA) and the Speech, Spatial and Qualities of Hearing Scale (SSQ) were administered. Results did not reveal any significant correlations between recall performance and self-reported residual difficulty with hearing aids, possibly because the recall performance of low performers on the modified SWIR test was comparable to that of the high performers on the original test. However, in the present study, SWIR performance was positively correlated with both Speech and Qualities domains of the SSQ. In other words, high performers reported better self-assessed speech understanding ability in various real-life situations. No significant correlations were found in the Spatial domain. High SWIR performers also reported less effort in aided listening. These results suggest that better cognitive performance under less demanding listening conditions indexing speech understanding and listening effort is associated with better self-rated aided listening experience. The modified SWIR test, which resembles real-life listening, can potentially be used to assess hearing aid outcome.
Challenging listening situations such as understanding speech in noise are known to require considerable effort. The objective of the present study was to identify which specific cognitive abilities are applied in listening situations that vary in complexity. Speech recognition threshold measurements (SRTs) were performed in a free-field setup. The TASCAR-toolbox (Grimm and Hohmann, 2014) was used to simulate five different listening situations, which varied along a number of perceptual dimensions (i.e., with or without dip listening, spatial separation, and informational masking). In a reference condition, a target (Göttingen Sentence Test) and directional masker (International Female Fluctuating Masker, IFFM; Holube 2015) were presented from 0° azimuth. While the target remained unchanged, diffuse cafeteria noise was added in the other conditions. Additionally, the direction (0° or ±135°) of and type of signal (IFFM or realistic conversation) for the directional masker were varied. For the analysis of the effects of the various masker conditions, SRT differences were calculated. In addition, a neuropsychological examination was performed, which included measurements of verbal working memory, executive functioning, and sustained, selected and divided attention. Groups of normal-hearing (NH, N=15) and hearing-impaired (HI, N=15) listeners participated. During the SRT measurements all HI listeners wore identical hearing aids fitted according to the NAL-NL2 formula. Correlation analyses showed different patterns of relations between the SRT differences and performance in the cognitive tests for the NH and HI listeners, suggesting that HI listeners rely on more than one particular cognitive ability for speech understanding.
Effects of hearing aid rehabilitation on listening effort
a systematic literature review

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Hearing impairment negatively affects speech perception and may increase listening effort, especially under adverse conditions such as in the presence of background noise. Previous research showed that hearing-aid rehabilitation can improve speech perception performance. However, it is not clear whether it influences listening effort during speech perception. The aim of this systematic review is to provide an overview of available evidence of the effect of hearing-aid rehabilitation on listening effort. English language articles were identified through systematic searches in PubMed, EMBASE, Cinahl, the Cochrane Library, PsycINFO and through reference checking from inception to August 2014. The primary search produced 12210 unique hits using the key-words: hearing aids OR hearing impairment AND listening effort OR perceptual effort OR ease of listening. Three researchers independently determined eligibility of the articles. In total, about 45 articles fulfilled the search and selection criteria of: experimental work on hearing aid technologies AND listening effort OR fatigue during speech perception. Most of the about 45 eligible studies (about 70%) measured perceived effort using subjective scales or questionnaires. Behavioral measures of listening effort mainly included dual-task paradigms. Finally, physiological measures such as provided by pupillometry, electroencephalography and functional magnetic resonance imaging objectively estimated listening effort. Some studies found that hearing-aid rehabilitation was associated with significant reductions of listening effort, while others failed to do so or even reported an increase of listening effort associated with hearing-aid rehabilitation. This review summarizes the available evidence on the effects of hearing aid rehabilitation on listening effort.
Poster no 63

Age-related hearing loss increases cross-modal distractibility

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Recent electrophysiological studies have provided evidence that changes in multisensory processing in auditory cortex cannot only be observed following extensive hearing loss, but also in moderately hearing-impaired subjects. How the reduced auditory input affects audio–visual interactions is however largely unknown. Here we used a cross-modal distraction paradigm to investigate multisensory processing in elderly participants with an age-related high-frequency hearing loss as compared to young and elderly subjects with normal hearing. During the experiment, participants were simultaneously presented with independent streams of auditory and visual input and were asked to categorize either the auditory or visual information while ignoring the other modality. Unisensory sequences without any cross-modal input served as control conditions to assure that all participants were able to perform the task. While all groups performed similarly in these unisensory conditions, hearing-impaired participants showed significantly increased error rates when confronted with distracting cross-modal stimulation. This effect could be observed in both the auditory and the visual task. Supporting these findings, an additional regression analysis indicted that the degree of high-frequency hearing loss significantly modulates cross-modal visual distractibility in the auditory task. These findings provide new evidence that already a moderate sub-clinical hearing loss, a common phenomenon in the elderly population, affects the processing of audio–visual information. We are currently running a functional neuroimaging study to investigate the neural correlates of increased cross-modal distractibility.
Working memory and communication in reverberant environments

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Working memory (WM) is a cognitive process involved in the simultaneous storage and processing of information necessary for speech understanding. Previous research has associated lower working memory capacity with reduced speech recognition under distorted conditions, including background noise, time-compressed speech, and hearing aid processing which alters the acoustic signal. However, no data are available examining the relationship between working memory and another prevalent type of distortion: reverberation. Reverberation is a source of spectrotemporal distortion resulting from delay in acoustic energy reaching the ear due to energy reflections. Reverberation is common in most listening conditions. The present study aimed to assess the relationship among listener working memory, environmental reverberation, and hearing aid processing.

Participants included older individuals with hearing loss. A reading span test was administered to assess individual listener working memory. Sentence recognition was assessed using a set of low-context sentences. Sentence reverberation varied across a range of reverberation times (0, 0.5, 1, 2, 4 s). The sentences were additionally processed across a range of hearing aid compression release times (12, 90, 800, 1500 ms). Intelligibility (objective) as well as clarity (subjective) measures comprised individual results.

Results suggest that individuals with higher working memory (i.e., more cognitive resources) are less susceptible to reverberant distortion and exhibit higher intelligibility in reverberation. This poster will also discuss the relationship of hearing aid processing with reverberation and working memory. Results reinforce previous data, indicating that working memory plays an important role in listening under adverse conditions. [Work supported by NIH and ASHFoundation]
Top-Down Manipulation of the Cochlear Biomechanics via the Olivocochlear Efferents: Modeling and Simulations

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There are growing evidences for existence of a functional descending network through which the central auditory system can modulate the early auditory processing, in a top-down manner. The medial olivocochlear efferent fibers project from the superior olivary complex at the brainstem into the inner ear. They are directly linked to the basal poles of the hair cells, forming synaptic cisterns. This descending network can activate nicotinic cholinergic receptors (nAChR) that increase the membrane conductance of the outer hair cells. The aim of the present work is to quantitatively investigate how such efferent-induced changes manipulate the cochlear responses. This is done by means of a biophysical model of the cochlea where the parameters of the model convey physiological interpretations of the mammalian cochlear structures. The simulations manifest that a doubling of the outer hair cell conductance, due to efferent activation, leads to a frequency-dependent gain reduction along the cochlear duct with its highest effect at frequencies between 1 kHz and 3.5 kHz and a maximum of approximately 10 dB gain reduction at 2 kHz. This amount of the gain inhibition and its frequency dependence are compared with the experimental data recorded from guinea pig, cat and human cochleae where the medial olivococlear efferents had been elicited by broad-band stimuli, showing a reasonable agreement. The simulations also indicate that the efferent-induced increase of the outer hair cell conductance increases the best frequency of the cochlear partitions, and hence modifies the frequency-position map (tuning pattern) of the cochlea, in the basal region.
INTRODUCTION: When beginning to learn to read, around age six, the incidence of minor hearing loss is about 15% and if minor, it is rarely identified by either parents or teachers since it may be unilateral or fluctuate and is usually not accompanied by any signs or inflammatory symptoms. OBJECTIVE: To observe the development of reading acquisition in children with minor hearing loss and in children with normal hearing through the reading of words and pseudo-words.

METODOLOGY: 24 children with normal hearing and 24 children with minor hearing loss were evaluated in two consecutive years (1st and 2nd grade). Reading tests using words and pseudo-words were administered in May in grade one and in February in grade two.

RESULTS: The children with minor hearing loss did worse in all tests administered. In the reading tests for words and pseudo-words in May, the 1st graders showed significant effects in group (F(1.46)=5.26; p = 0.026) and in lexicality (F(1.46)=5.57; p = 0.023); and there was still a marginally significant group X lexicality interaction (F(1.46)=2.91; p = 0.095). In February the 2nd graders once again manifested significant effects in group (F(1.44)=4.28; p=0.045) and in lexicality (F(1.44)=11.53; p=0.001).

CONCLUSION: We may conclude that minor hearing loss interferes with the development of basic skills required for beginning level reading - and may impede the establishment of two channels of identification of the written word: the phonological (sub-lexical) and the visual-orthographic (lexical).
Poster no 67

Hearing Threshold, Auditory Work Memory (in quiet and noise) and Auditory Discrimination in Pianists

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Aim: Study hearing thresholds, auditory discrimination and auditory memory in quiet and noise in pianists.

Methods: Pianists under the age of 50 years and another pianists over 50 years old were evaluated; all right-handed, with no history of ear disease or ototoxic medication. All the participants had type A tympanogram and bone conduction thresholds with a gap lower or equal to 10dB. In the auditory discrimination study, teachers heard a two syllable list words and a pseudowords list. They were asked to repeat both words and pseudowords as heard. In the auditory memory study, in quiet and noise, pianists heard stes of two, three, four and five pseudowords.

Results: Pianists over the age of 50 years showed worse hearing thresholds than those who were under the age of 50 years. Differences over 10 dB were verified from 3kHz in both ears between the two group’s mean thresholds, with statistical differences at 4kHz and 8kHz in the right ear, and at 3kHz, 4kHz, 6kHz and 8kHz in the left ear. Meaningful statistical differences were not found in the auditory discrimination and auditory work memory tests between the two groups, although the group aged over 50 years was slightly better in the auditory memory test in presence of noise.

Conclusions: The results seem to indicate the non-reduction in the abilities of auditory discrimination and auditory work memory in pianists with increasing age, even revealing greater training of auditory memory in adverse environments in pianists older than 50 years of age.
Benefit of a computer-based auditory phoneme-discrimination training for CI listeners – A matter of age?

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During the process of acclimatization to the electrical input after a supply with cochlear implantation, a specific auditory training may be a useful tool of completion in the rehabilitation process for CI listeners. The aim of our study was to show the impact of such a specific auditory training with phoneme-discrimination tasks on speech perception even in the elderly CI users.

In a pretest-post-test design participants were randomly assigned to the training (n=15) or control group (n=12). Within three weeks, the training group was instructed to train in phoneme discrimination via computer, twice a week. Before and after training, speech recognition tests in moderate and difficult noise (+5 dB SNR and 0 dB SNR, respectively) were administered, as well as six months after the training (follow-up). The control group was tested and retested within one month and received no training.

Additionally to significant improvements for the phoneme-discrimination task during training, speech perception in moderate noise for the training group participants improved significantly, comparing pre- and posttraining scores and maintained over an extended period. No significant changes were noted in the difficult noise conditions. The speech perception measures for the control group remained unchanged comparing test- and retest scores. No significant effect of age on the training effect was observed.

Specific auditory phoneme-discrimination training partially improves speech recognition in noise in experienced CI listeners. Moreover, elderly motivated CI listeners may benefit in a similar way from such auditory training as younger CI users. Additional research is needed to optimize auditory training.
Recent work suggests that semantic information enhances processing of degraded speech for hearing-impaired (HI) listeners. Based on results from our lab showing that prior knowledge influences the perceptual clarity of degraded speech more when semantic coherence is low for normal-hearing listeners, we predicted a similar effect for HI listeners. We investigated here whether prior knowledge enhances the perceived clarity of degraded speech for HI listeners and whether this effect is dependent on semantic coherence. Native Swedish speakers with moderate sensory hearing-loss listened to spoken Swedish sentences that were either clear or degraded by noise-vocoding, and rated their clarity on a 7-point scale. The sentences were semantically high or low coherent. Each spoken word was preceded (200 ms) by either its text equivalent (matching cue) or a consonant string of matched length (non-matching cue). Preliminary results from 8 participants showed that the perceived clarity of degraded sentences was greater when they were coherent, $F(1,7) = 6.54; p = .038$, and when they were preceded by a matching cues, $F(1,7) = 29.96; p < .001$. A marginal Cue x Coherence interaction, $F(1,7) = 5.16; p = .057$, surprisingly indicated that the prior knowledge provided by cues influenced the perceptual clarity of degraded sentences more when coherence was high for HI listeners. Correlations between clarity ratings and independent measures of cognitive abilities will be reported to advance our knowledge of factors that can promote and optimize degraded speech perception for persons with age-related hearing loss.
Degraded speech is rendered more intelligible both by semantic coherence and preceding text cues. Recently, we showed that the perceptual clarity of noise-vo-coded speech (NVS) is still enhanced by semantic coherence when cues are provided and that prior knowledge enhances perceptual clarity of NVS when semantic coherence is low (Signoret et al., 2015). Here, we investigated the neural correlates of this interaction. Twenty participants listened to sentences and performed an unrelated attentional task during sparse-imaging fMRI. The sentences had high or low semantic coherence, and were either clear, degraded (6-band NV) or unintelligible (1-band NV). Each spoken word was preceded (200 ms) by either a matching cue or a consonant string. Preliminary results revealed significant main effects of both Coherence and Cue in the superior temporal gyrus bilaterally and a significant interaction between Coherence and Cue when speech was degraded, in superior and middle temporal gyri bilaterally and left precentral gyrus. Investigation of this interaction revealed greater activation for high compared to low coherent sentences when cues were provided in the left-lateralized regions and greater activation without than with cues when semantic coherence was low in bilateral regions. The opposite contrasts elicited no significant activation. This pattern of results indicates that the increases in perceptual clarity of NVS attributable to semantic coherence and prior knowledge are supported by similar neural mechanisms organized in bilateral temporal regions, but that when perceptual clarity is optimized by both factors, it is supported by left-lateralized mechanisms.
All persons are, regardless of their hearing status, more or less exposed to disturbing sounds and their negative effects. Disturbance from sounds might have negative psychosocial effects in form of masking, stress, sound fatigue as well as distraction. When considering degree of annoyance of disturbing sounds one has to take into account the impact of cognitive capacity.

This study comprised of rating tests for loudness and annoyance by 21 participants with normal peripheral hearing function performed at the Audiology Research center, Örebro university hospital, Sweden. The aim of the study was to investigate if normal hearing subjects rating of loudness and annoyance for disturbing sounds could be explained by acoustic features of the sounds, by hearing functions or by cognitive function. The result of the study indicate that the perception of sounds are depending on several factors, separate or in combination, and results of the behavioral tests will be presented.
Switching neural representations with auditory prostheses:
influence of cognitive factors on success with novel coding strategies

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New recipients of cochlear implants (CIs) learn to make better use of the auditory cues provided by their devices over many months, but new coding strategies are often tested in experienced CI listeners with crystallized internal models of speech sounds. Novel CI coding strategies change the stimulation patterns and thus the neural representations of sounds in the brain. One challenge of evaluating the impact of these changes on speech outcomes is overcoming the effects of prior listening experience. This study investigates the role of cognitive factors on the success of novel coding strategies. In a first experiment, we altered stimulation by switching from a monopolar to a focused-multipolar stimulation mode. While psychophysical measures indicate better sensitivity to spectral features in all subjects with this manipulation, acute measures of speech understanding are mixed across subjects. However, our results show that acute changes in speech scores with the focused stimulation strategy are negatively correlated with the level of long-term speech learning previously experienced with the clinical device. Subjects whose speech scores reached asymptote early showed more acute benefit with focusing; those with speech scores that increased over several months tended to do worse with acute focusing. In a second experiment, another set of subjects was switched to a temporally sparse coding strategy. After 18 weeks of take-home experience, subjects’ relative levels of success with the sparse strategy correlate with working memory scores. Together, these results suggest an important role of cognition in the ability to switch to new neural representations of sound.
Poster no 73

Independent effects of acoustics and intelligibility
on the neural oscillation patterns in
response to speech

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Speech consists of a mix of periodic (voiced) and aperiodic (unvoiced) segments with very distinct acoustic properties. We have recorded cortical EEG signals in response to vocoded speech that was either completely aperiodic (noise-vocoded), had a natural mix of periodicity and aperiodicity, or was completely periodic. Sorting the single trials according to the spoken behavioural responses allowed us to examine effects of periodicity while controlling for intelligibility, and vice versa. Both factors were found to strongly influence the neural oscillation patterns over time. Firstly, unnatural-sounding fully voiced speech was found to strongly differ from the other two conditions. The most prominent differences in induced activity were found to be more theta (4–8 Hz), less low beta (12–17 Hz), and less high gamma (30–100 Hz) power. This suggests that even after controlling for differences in intelligibility, subjects found it more demanding to process this condition. Secondly, when comparing fully voiced intelligible and unintelligible speech directly, the former was found to induce much stronger power differences relative to baseline level. We observed more power in the delta range (1–4 Hz) and less power at higher frequencies (low beta and gamma), while no significant difference were observed in the alpha band (7–13 Hz). In summary, these results show that acoustic characteristics and intelligibility independently shape the neural response to speech signals and that care has to be taken to disentangle both factors.
In the present study we aimed to investigate individual differences in cognitive inhibition, WMC, and how they relate to performance on a speech-recognition-in-noise task. Sixteen young normally-hearing individuals were presented with a cognitive test battery, as well as a sentence corpus masked by 5 different maskers, targeting 80% speech-recognition. One masker was a slightly modulated (10%) speech-shaped noise (SSN), 2 maskers were constructed by modulating the SSN with the envelopes from a single female talker, and the international speech test signal (ISTS). We also masked the target sentences with the ISTS, and a single female talker reading a passage in a Swedish newspaper. Our results showed that cognitive inhibition is significantly related to performance when maskers with meaningful, semantic information is used. The results further indicate that young normally-hearing individuals can take advantage of temporal and spectral dips to fill in missing information. Our findings suggest that choice of speech material is of importance for the outcome in speech-recognition-in-noise tasks. We further propose that tasks of cognitive inhibition can be used to predict performance in a speech-recognition task.
Cognitive inhibition, WMC and speech-recognition-in-noise

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Cognitive abilities are important for a number of human attributes, such as making sense of communication, holding information active in memory, and making decisions. When it is the goal to focus on a single target voice, and resist intrusions from irrelevant information, cognitive inhibition can aid us in our endeavour. Cognitive inhibition is thought to support and co-operate with working memory. Abilities such as cognitive inhibition and working memory are also important for speech processing, even more so when listening to speech under adverse conditions. In order to assess different difficulties that can arise in everyday listening situations, it’s of importance to have solid methods for measuring cognitive abilities. In the present study we present a task assessing cognitive inhibition, and how it relates to individual working memory capacity (WMC), and speech-recognition-in-noise. Forty-six young normally-hearing individuals were presented with a cognitive test battery, as well as a speech-in-noise test. Our results suggest that individuals with high WMC, also exhibit good cognitive inhibition. The results also indicate that those who perform well in the cognitive inhibition task need less favourable signal-to-noise-ratios in the speech-recognition task. Our findings indicate that capacity to resist semantic interference can be used to predict performance on speech-recognition tasks when listening under adverse conditions.
Increasing evidence suggests that good listening skills require top-down cognitive factors, such as attention. The Test of Attention in Listening (TAiL) has been designed to quantify auditory selective attention using simple, non-verbal stimuli. During the task, the listener is asked if a sequential tone pair has the same or different task-relevant feature (tone frequency or location). Through different combinations of task-relevant and -irrelevant features, the test provides measures of distraction and conflict resolution.

Using the TAiL, this study investigated how auditory distractibility and conflict resolution changes with age. We manipulated the difficulty of the task by varying the frequency difference between the two tone-pips. Counterbalanced blocks of ‘easy’ and ‘hard’ perceptual discriminability, 20 and 4 semitones difference respectively, were used.

Forty-five younger children (aged 4-7), 34 older children (aged 8-11) and 21 adults (aged 17-29) were tested on the TAiL’s attend-frequency task via a game interface. Results show that all age groups showed similar levels of distractibility, regardless of the task difficulty. However, the younger children (aged 4-7) were significantly less conflicted than older children and adults in the ‘hard’ condition, yet made no more errors.

These results are similar to those found in vision, where younger children do not automatically ‘fuse’ different stimulus features within a task, whilst older children and adults do. Therefore, younger children may be less conflicted and more able to detect sensory discrepancies because they are only able to use/perceive one feature of the stimulus.
Introduction: There is no standardized material to assess auditory processing (AP) in the Norwegian-speaking population. The purpose of this research was to obtain normative data for AP tests for Norwegian speaking children aged 7-12 years.

Methods: The Norwegian AP tests comprised of four speech tests including Filtered Words, Competing Words, Dichotic Digits 4 and Norwegian HIST Speech in Noise and four non-speech tests including Gaps in Noise (GIN), Frequency Pattern Test, Duration Pattern Test and Binaural Masking Level Difference (BMLD). 268 normal hearing children were assessed to obtain the normative data.

Results: The study ended in June 2014 and the article is in writing. Preliminary results for the BMLD and GIN show no significant difference between gender or age between the children, selected alpha level was 0.05. This corresponds with findings in international studies. Regarding the remaining tests, there is no significant difference in gender or age between the 7-8, 9-10 and 11-12 years old children.

Conclusion: Final results and suggested normative data will be presented at the CHSCOM 2015 and a shortened test battery suggested.
Honking is just noise (or just about):  
the effect of energetic masking on  
recognition memory for spoken words

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Previous research indicates that listeners encode both linguistic and indexical specifications of the speech signal in memory. Recent evidence suggests that non-linguistic sounds co-occurring with spoken words are also incorporated in our lexical memory. We argue that this "sound-specificity effect" might not be due so much to a word-sound association as to the different acoustic glimpses of the words that the associated sounds create. In several recognition-memory experiments, we paired spoken words with one of two car honk sounds and varied the level of energetic masking from exposure to test. We did not observe a drop in recognition accuracy for previously heard words when the paired sound changed as long as energetic masking was controlled. However, when we manipulated the temporal overlap between words and honking to create an energetic masking contrast, accuracy dropped. The finding suggests that listeners encode irrelevant non-speech information in memory, but only in certain contexts. Calling for an expansion of the mental lexicon to include non-speech auditory information might be premature. Current work is investigating the effect in non-native listeners of English, and whether maskers that are more integral to the words and hence more difficult to segregate lead to a more robust effect.
The polyphonic brain: Extracting the neural representation of tone onsets for separate voices of polyphonic music using ERPs

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Several cortical signatures (event-related potentials and auditory steady-state evoked potentials) have been found to indicate the degree of perceptual separation/coherence of consecutive sounds that leads to the percept of separate streams. However, these electrophysiological indices of auditory stream segregation have been derived with highly structured experimental paradigms and by averaging across large number of similar sound events, a listening scenario that is far from the ‘soundscapes’ of everyday life. Here, we introduce a novel EEG approach to extract brain responses to tone onsets in continuous approximately naturalistic music stimuli. We explore whether these EEG signatures can reveal a neural representation of perceived separate streams that correspond to the voices of three instruments that form a polyphonic music-like stimulus. Audio clips (resembling minimalistic electro-pop) were presented to 11 subjects with normal hearing, either in a polyphonic version (drums, bass, keyboard) or in the corresponding three solo versions. For each instrument we trained a spatio-temporal filter on the respective solo trials to extract an N1/P2-like response to note onsets. Applying these filters to 64-channel EEG recorded during the polyphonic presentations the note onset structure of the embedded solo voices could be reconstructed with different consistency between subjects. Moreover, the results indicated that focusing attention on a particular instrument could improve the reconstruction quality. Our results are a proof-of-concept that N1/P2 responses to sound onsets constitute a promising starting point for tracking perceived streams in the listener’s EEG. Moreover, our results show that these reconstructions may inform about the attentional state of the listener.
Spatially-separated sources can reduce cognitive load in a cocktail-party situation: Evidence from near infrared spectroscopy

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Cognitive load is a key factor in understanding speech communication in adverse situation. Here, we explored the effect of cognitive load in a classical cocktail-party paradigm. A speech-in-speech intelligibility task was performed using the coordinate response measure (CRM) corpus. The influences of target-to-masker ratio (TMR; -12 dB, -4 dB, and +4 dB) and the spatial relationship (co-localized or spatially separated by 1200) over response accuracy and prefrontal hemodynamic responses were investigated. Prefrontal activity was measured using a 16-channels functional near infrared spectroscopy (fNIRS). fNIRS is an optical brain monitoring method that has been successfully used to detect changes in oxygenated hemoglobin concentration associated with cognitive load. Fifteen normal-hearing participants took part in the experiment. As expected, in the spatially-separated condition, performance was close to ceiling. Consistently, a lower prefrontal activation was also observed in this condition. We provide here a first important result suggesting that spatially-separated sources can reduce cognitive load in a cocktail-party situation. Hence, this study shows that fNIRS is a suitable device to investigate speech-in-speech intelligibility and especially to assess the design of spatially–separated stimuli in ecological environments.
A role for prosody in immediate repetition tasks

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Non-word repetition has been identified as a potential marker for language difficulties in children with language impairment and children using cochlear implants. Immediate repetition is a complex task, relying on adequate hearing, processing and language skills, as well articulation. Performance is also dependent on features of the stimuli that are to be repeated, such as length, wordlikeness and phonological complexity. Controlling for each of these factors is crucial for drawing conclusions about what underlies repetition difficulties in a given population. In the present study, a prosodically controlled word- and non-word repetition task was administered to 44 typically developing, Swedish-speaking children aged four to six years. Focus of the analyses was on developmental differences, and on how the two different tonal word accents of Swedish influence performance. Repetition accuracy for both words and non-words increased with age. Further, tonal word accents I and II provided different conditions for segment repetition in favor of accent II during both word repetition and non-word repetition for older children, but only during word repetition for younger children. This suggests age-dependent differences regarding how prosody is stored and integrated with segments. Upcoming studies will investigate word- and non-word repetition in relation to various measures of language and cognition in children with hearing impairment and children with language impairment.
Differences in Speech Recognition Between Children with Attention Deficits and Normally Developed Children Disappears when Exposed to 65 dB of White Noise

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The most common neuropsychiatric condition in the childhood population is attention deficit hyperactivity disorder (ADHD) affecting approximately 5% of the population. ADHD is distinguished by poor functioning in various cognitive tasks but also by sensory and perceptual dysfunctions often leading to school failures. Prior research has mainly focused on executive functioning were differences are explained by deficits in pre-frontal cortex activation. Less notice has been given to sensory perception and subcortical functioning in ADHD. However, recent research has shown that children with ADHD diagnosis have a deviant auditory brain stem response compared to healthy controls. The aim of the present study was to investigate if the speech perception threshold differs between attentive and inattentive children and if this difference in speech perception could be reduced by through white noise exposure. Previous research has namely shown that children with attention deficits can benefit from noise exposure during cognitive tasks; here we investigate if this benefit is present during a perceptual task as well. For this purpose we used a modified Hagermans speech recognition test were children with and without attention deficits performed a speech recognition task to assess the speech recognition threshold in silence and in 65 dB of white noise. Results showed that that the inattentive group displayed a higher speech perception threshold than control children. This difference in speech perception disappeared in the white noise condition. From this we conclude that inattention partly can be explained by perceptual limitations that can be ameliorated through white noise exposure.
Informational interference from a competing talker: a thought-provoking but elusive construct

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A competing talker can impair speech processing through both energetic masking and informational, cognitive aspects of masking. We refer to the latter as informational interference. We hypothesized that informational interference depletes processing resources that could otherwise be allocated to recognizing and understanding target speech. Consequently, informational interference should be more pronounced for target sentences with high processing demands (complex syntax) than for sentences with low processing demands (simple syntax). Furthermore, informational interference should be particularly marked when participants’ own processing demands are increased, as with non-native listeners. Using a speeded picture selection task, we assessed native and non-native listeners’ understanding of subject-relative (simple) and object-relative (complex) sentences, played against a competing talker vs. a matched energetic mask, at various signal-to-noise ratios (SNRs). Although object-relative sentences were more demanding than subject-relative sentences, the competing talker did not affect performance more than did energetic mask controls. This pattern was comparable for native and non-native listeners, and across SNRs. Moreover, individual differences in working memory were not related to differences in the speeded-selection task, regardless of the mask. Eye-tracking and pupillometric versions of this experiment also yielded similar results. Thus, contrary to prior research, we found no evidence that a competing talker requires greater processing resources than energetic masking alone. To address this discrepancy, an ongoing study aims to determine whether the semantic content of the competing talker’s utterances modulates attention to the target.
The onset of presbycusis in middle-aged persons

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As we age, we are often faced with upcoming speech understanding difficulties that later on gradually increase. It is known that presbycusis (hearing loss attributed to aging, despite normal health and without over-exposure to environmental noise) commonly has its onset in middle-age. Yet, hearing impairments are often detected and diagnosed much later, when speech intelligibility problems become more and more severe, inevitably leading to a demand for care.

The goal of the current study is to gain insight in the onset of communicational problems in a middle-aged population and in determining which measure is most sensitive in detecting these problems. Pure-tone averages, speech in noise data and oto-acoustic emissions were evaluated, together with self-report measures for a large, random sample of persons between 40-60 years of age. Preliminary results confirm that persons as young as 45 years of age show deteriorated self-report measures, whereas objective measures only start showing deteriorations at the ages of 50-55 years of age.
Dancing to music improves song learning in children with cochlear implants

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Music perception of cochlear implants (CI) users is constrained by the absence of salient musical pitch cues, yet musical timing cues are largely preserved by current devices. The task at hand becomes one of optimizing the cues that are available to CI users by exploring ways that musical cues are encoded simultaneously across multiple modalities. We examined how learning tasks that engage active music listening and movement through dance might enhance the song learning skills of deaf children with CIs. CI children learned new songs in two contexts: a) by listening alone, 2) dancing to music. A subsequent task tested their ability to identify the original version, as well as melodic and mistuned renditions of songs. Our findings indicate that movement in conjunction to music listening leads to gains in enhancing identification of novel songs in the short-term. Furthermore, kinematic analyses of CI children’s dancing indicate greater potential for learning in the long-term by their ability to move in synchrony to the beat at levels that are comparable to those of hearing age-matched peers. Methods that encourage CI children to track timing with body movements may be particularly effective in consolidating representations of music in memory than those achieved by listening alone.
Reading strategies and orthographic learning in children with hearing impairments and children with dyslexia

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Reading skills in children with moderate to profound hearing impairments (HI) have been reported to vary considerably. These children have previously been found to have problems in tasks on phonological skills and language, which are often considered prerequisites for successful reading acquisition. Children with dyslexia often experience similar problems with phonological skills, language, and reading but for different reasons.

The current study explored the cognitive factors related to different reading strategies (phonological and orthographic decoding) and orthographic learning in three groups of 9-year-old children: 18 children with HI (7 with hearing aids and 11 with cochlear implants), 19 children with dyslexia, and 35 children with normal hearing and typical reading development (NH).

The children with NH had the highest performance in all tests of decoding and orthographic learning followed by the children with HI and then the children with dyslexia. The children with HI had specific problems with phonological decoding but performed relatively well on orthographic decoding measures, compared to the other two groups. Word decoding fluency and orthographic learning were strongly related to visuo-spatial working memory (VWM) in the children with HI and the children with dyslexia but not in the NH group. These results support the hypothesis that children with HI and children with dyslexia use a reading strategy where they memorize whole written words to a greater extent than other children. Their success with this reading strategy seems to be dependent on visual working memory capacity.
Investigating the effect of competing talkers on speech processing load as shown by task invoked pupil-dilation

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Understanding speech is a complex process that can become demanding especially in a situation when the speech signal is disturbed due to interfering noise. Koelewijn et al. (2012) reported that the type of masker affects processing load especially when the masker contains semantic information. Build on studies by Koelewijn and colleagues (2012a,b, 2014), the objective of this study was to investigate the effect of competing speech information on processing load during speech perception indicated by task-evoked pupil dilation. In contrast to these previous studies, the effect of masker type on processing load was investigated using Danish sentences. For that purpose, pupil dilation was measured at controlled intelligibility levels (at 50% and 84% intelligibility) with fluctuating noise and with a competing talker. In addition, pupil dilation is recorded in the presence of four competing talkers (4-talker-babble). An interfering effect of semantic information from both the single-talker and the 4-talker babble on processing load is hypothesized. We expected to find an increased processing load, indicated by increased tasked-evoked pupil dilation, for the single-talker masker compared to the fluctuating noise masker. Moreover, in order to obtain a similar speech recognition performance, processing load was expected to be highest for the 4-talker babble. Our findings give an insight into the detrimental effect of competing speech information on sentence processing demands.
Objective: This study examined the relationship between hearing impairment and mental distress. We hypothesised that fear of negative evaluation by others and avoidant communication strategies are associated with increased symptoms of depression.

Design: Hearing-impaired adults (N=105) who signed up for a stress management course completed the Hospital Anxiety and Depression Scale (HADS), the Fear of Negative Evaluation Scale (FNE), and the Conversation Tactics Checklist (CONV). The participants’ ratings of subjective hearing disability were assessed on a 5-point Likert scale and pure-tone audiometry obtained. Hierarchical multiple regression analysis was used to assess associations between fear of negative evaluation, avoidance, and symptoms of depression.

Results: Objective hearing impairment was moderate or less for 81% (n=87) of participants, and the correlation between subjective hearing disability and objective hearing impairment was not significant. Multiple regression analysis showed that fear of negative evaluation and avoidant communication strategies contributed significantly to the variance in depression symptoms, and the total explained variance was 41.7% \[F (5, 93) =13.32, p = 0.000\]. Subjective and objective hearing disability did not make significant contributions.

Conclusion: Symptoms of depression appear to be closely related to fear of negative evaluation by others and use of avoidant communication strategies. Future clinical studies should address whether targeting these problems in rehabilitation interventions decreases depressive symptoms among hearing-impaired individuals.
**A cognitive therapy program for hearing impaired employees suffering from mental distress**

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Objective: To develop a cognitive therapy program to reduce mental distress among hearing impaired employees.

Design: In a pilot study we measured the development of mental distress and avoidant coping among hearing impaired employees. Levels of mental distress were assessed using the Hospital Anxiety and Depression Scale (HAD), and the extent of avoidance with Conversation Tactics Checklist CONV(AVOID). The findings were compared with the development in a treatment as usual (TAU) sample.

Study sample: Fifteen participants with an equal distribution of male and female participants (M=49.2 years) took part. The majority had mild to moderate hearing impairment.

Results: The program appeared to be feasible and the adherence was good. The mean depression score was identical at pre- and post-intervention in the intervention group, and increased from 2.9 (SD 2.1) to 3.1 (SD 2.0) in the TAU group. Symptoms of anxiety [(p<.01), 95 % CI (.82, 3.98)] and avoidant communication [(p<.05), 95% CI (.5, 4.61)] decreased significantly in the intervention group, while an opposite pattern was observed during the TAU program.

Conclusions: The program showed promising results. However, the preliminary results should be further investigated in a randomized controlled trial using a larger sample.
Electroencephalographic features during listening:
Effort, performance, and trial-to-trial variability

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Recent work has identified potential indices of "listening effort" in theta (~4-7 Hz) and alpha band (~8-12 Hz) M/EEG. Several other studies have found modulations of higher frequency M/EEG bands during auditory processing. Here, high-density EEG was collected while listeners performed a sentence recognition task under different signal-to-noise ratios (SNRs; -12 to 12 dB). Data was decomposed with independent component analyses (ICA). Independent component (IC) processes were subsequently clustered based on spectra, estimated equivalent current dipole location, and spectral dynamics. Several IC process clusters displayed task-related spectral perturbations in theta, alpha, and beta frequency bands. Corroborating previous work, sustained increases in theta (1 medial frontal IC cluster) and alpha power (2 parietal IC clusters) were greater for low SNRs. Single-trial data was used to train a multilayer perceptron (2 hidden units) to discriminate individuals’ 20% most inaccurate trials from the 20% most accurate trials in the -12 dB SNR condition. The network correctly classified 83% of trials. Analysis of network weights revealed two different combinations of single-trial EEG features that were associated with accurate performance: 1) relatively high theta and low-beta power for a medial frontal cluster of ICs; and 2) relatively high alpha power in parietal clusters of ICs prior to sentence presentation, followed by relatively low alpha power during retention. Results are discussed in the context of listening effort work and a large body of research examining attention and working-memory processes in audition.
Previous studies have demonstrated that speech recognition in noise is associated with hearing aid compression release settings and cognitive processing speed. This study investigated the effects of Cognitive processing speed and Digital Signal Processing settings (linear amplification without noise reduction, linear amplification with noise reduction and non-linear amplification with (fast-acting compression without noise reduction) on the performance of speech recognition task in noise in elderly hearing aid users. Two hundred elderly (mean age = 61 years) experienced hearing aid users with sensorineural hearing loss participated in the study. Individual measurements of Cognitive processing speed (rapid automatic naming test), Speech recognition in noise (Hagerman test) were obtained and used to predict a successful outcome. The results will be presented and the potential clinical implications in the rehabilitations of elderly hearing aid users discussed.
A Little Knowledge is a Dangerous Thing: Foreign Language Proficiency Increases Susceptibility to Interference from that Language

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Research on bilingual listeners’ perception of speech in competing speech in a second language suggests that a non-native language masker may interfere less with understanding native language target speech than vice versa. One reason for this is that listeners may be more distracted by the presence of recognizable words in the masking speech when it is in their native language, and/or may be under greater cognitive load when trying to understand target speech in a less familiar language (Lecumberri, et al. 2010). In both cases, degree of interference should correspond to second language proficiency: Compared to less proficient listeners, those who are more proficient in a given language should experience greater interference when it serves as a masker, and less interference when it serves as a target. In this study, native speakers of Dutch with varying degrees of English proficiency as assessed by education level and a written test were asked to repeat sentences spoken in both Dutch and English masked by sentences in both languages (fully crossed design) under both blocked (consistent target and masking language across trials) and mixed (varying masker language across trials) conditions in an adaptive tracking paradigm. Pupil dilation was measured as an index of cognitive load. Preliminary analyses (N=14) suggest that listeners with greater English proficiency experienced increased cognitive demand from an English masker in English target conditions while lower proficiency listeners did not. However higher proficiency listeners did not experience any benefit compared to lower proficiency listeners when hearing English masked by Dutch.
Cognitive processing load during listening is reduced more by decreasing voice similarity than by increasing spatial separation between target and masker speech

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We investigated changes in speech recognition and cognitive processing load attributable to decreasing similarity between target and masker speech. We presented masker voices with either the same (female) gender or different gender (male) as the target speech, and/or spatially separated the target and masker speech using HRTFs. We assessed the relation between speech perception performance, the pupil response and cognitive abilities in 24 normal-hearing adults. We hypothesized that the pupil response, a measure of cognitive processing load, would be larger for co-located maskers and for same-gender compared to different-gender maskers. We further expected that better cognitive abilities would be associated with better speech perception and larger pupil responses, as the allocation of larger capacity may result in more intense mental processing. In line with previous studies, the performance benefit from different-gender compared to same-gender maskers was larger for co-located masker signals. The performance benefit of spatially-separated maskers was larger for same-gender maskers. The pupil response was larger for same-gender than for different-gender maskers, but was not reduced by spatial separation. We observed associations between better perception performance and better working memory, better information updating, and better executive abilities. The pupil response was not associated with cognitive abilities. Thus, although both gender and location differences between target and masker facilitate speech perception, only gender differences lower cognitive processing load. Increasing target-masker voice dissimilarity may facilitate target-speech perception at a later (cognitive) processing stage than increasing spatial separation. The pupil response provides information that complements speech intelligibility data.
Auditory training to ignore random babble noise with VCV tasks

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Perceptual learning studies are not new in hearing research. However, in the literature, fewer researchers have attempted to train hearing aid (HA) or cochlear implant (CI) users to better understand speech material in noisy environment. Typically, auditory perceptual learning studies present speech with no background noise or other competing environmental factors. This study focuses on training subjects to ignore random babble noise. The objective of this investigation was to assess whether a learning effect could be obtained from training normal hearing listeners under random babble noise environments. Twenty normal-hearing English native speakers (aged 18 to 40) participated in this experiment. They were randomly assigned to a random babble noise training group or control group. Both groups were required to do a pre- and post-test with vowel consonant vowel (VCV) stimulus (including eight consonants /b/, /d/, /f/, /g/, /k/, /m/, /n/, /p/ with male and female voices) in random babble noise. The random group was trained with VCV stimulus in random background noise for three days training sessions (1 hour per day) between the pre-and post-test, while the control group was not trained. Participants' performance significantly improved between pre and post VCV random babble noise tests for both two groups. In addition, the improvement for the random training group was significantly larger than the control one. So hearing performance was improved under the training of random babble noise environments.
## Participants

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