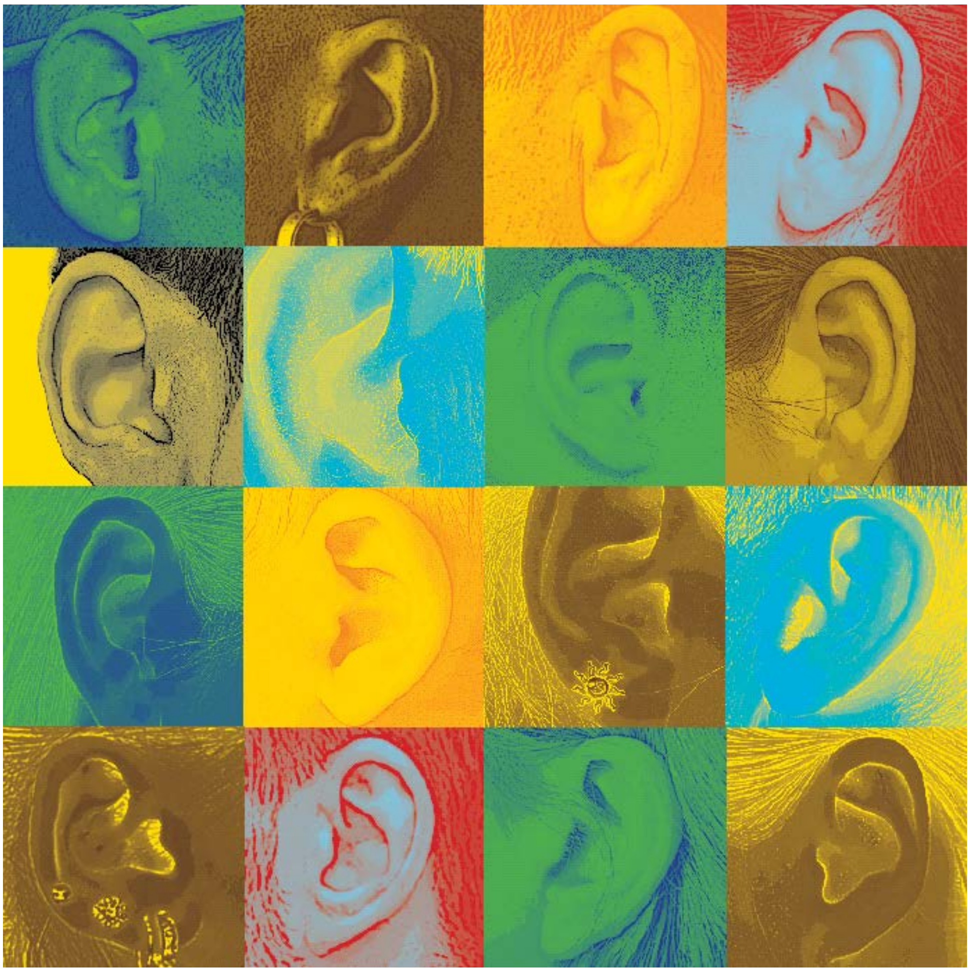
5th

International Symposium on Auditory and Audiological Research

ISAAR 2015

"Individual hearing loss – Characterization, modelling, compensation strategies"



August 26-28, 2015

Hotel Nyborg Strand, Denmark

Programme and abstracts

About ISAAR

The “International Symposium on Auditory and Audiological Research” is formerly known as the “Danavox Symposium”. The 2015 edition corresponds to the 26th symposium in the series and the 5th symposium under the ISAAR name, adopted in 2007. The Danavox Jubilee Foundation was established in 1968 on the occasion of the 25th anniversary of GN Danavox. The aim of the foundation is to support and encourage audiological research and development.

Funds are donated by GN ReSound (formerly GN Danavox) and are managed by a board consisting of hearing science specialists who are entirely independent of GN ReSound. Since its establishment in 1968, the resources of the foundation have been used to support a series of symposia, at which a large number of outstanding scientists from all over the world have given lectures, presented posters, and participated in discussions on various audiological topics.

More information can be found at www.ISAAR.eu. Proceedings from past symposia can be found at www.audiological-library.gnresound.dk.

Cover illustration by Wet DesignerDog (www.wetdesignerdog.dk)
with thanks to Eva Helena Andersen

Welcome to ISAAR 2015

The general topic of the ISAAR 2015 symposium is "Individual hearing loss – Characterization, modelling, compensation strategies". The concept is to consider this topic from different perspectives, including current physiological concepts, perceptual measures and models, as well as implications for new technical applications.

The programme consists of invited talks as well as contributed talks and posters. The symposium is divided into five sessions, to which the following speakers have been invited:

1. ***Characterizing individual differences in hearing loss***
   Judy Dubno, Larry Humes, Agnès Léger, Andrew Oxenham

2. ***Genetics of hearing loss***
   Karen Steel, Hannie Kremer, Guy van Camp

3. ***Hidden hearing loss: Neural degeneration in ”normal” hearing***
   Christopher Plack, Kate Fernandez, Hari Bharadwaj, Jane Bjerg Jensen

4. ***Modelling individual hearing impairment***
   Enrique Lopez-Poveda, Michael Heinz, Volker Hohmann

5. ***Individualized diagnostics and compensation strategies***
   Brent Edwards, Harvey Dillon, Deniz Başkent

In addition to these scientific presentations, one of the objectives of ISAAR is to promote networking and create contacts between researchers from different institutions in the fields of audiology and auditory research. ISAAR is a great opportunity for young scientists to approach more experienced researchers and vice-versa.

After the symposium, written versions of the presentations and posters will be published in a proceedings book. All participants will receive a copy of the ISAAR 2015 proceedings.

The organizing committee and the Danavox Jubilee Foundation wish you an interesting and fruitful symposium. Happy networking!

Wednesday 26 August

08:30-10:00	*Registration and hanging of posters*
10:00-10:10	Torsten Dau: Welcome and introduction to the symposium
Session 1:	**Characterizing individual differences in hearing loss**
10:10-10:40	Judy Dubno: Characterizing individual differences: Audiometric phenotypes of age-related hearing loss
10:40-11:10	Larry Humes: Individual differences in auditory perception among older adults with impaired hearing
11:10-11:30	*Coffee break*
11:30-12:00	Agnès Léger: Beyond the audiogram: Influence of supra-threshold deficits associated with hearing loss and age on speech intelligibility
12:00-13:30	*Lunch*
13:30-14:00	Andrew Oxenham: Characterizing individual differences in frequency coding: Implications for hearing loss
14:00-14:20	Sarah Verhulst: Interrelations between ABR and EFR measures and their diagnostic power in targeting subcomponents of hearing loss

Wednesday 26 August

Session 1: Characterizing individual differences in hearing loss (cont.)

14:20-14:40	Kristina DeRoy Milvae: Is cochlear gain reduction related to speech-in-babble performance?
14:40-15:00	Federica Bianchi: Effects of cochlear compression and frequency selectivity on pitch discrimination of unresolved complex tones
15:00-15:30	*Coffee break*

Session 2: Genetics of hearing loss

15:30-16:00	Karen Steel: What mouse mutants tell us about deafness
16:00-16:30	Hannie Kremer: Genetic defects and their impact on auditory function
16:30-17:00	Guy van Camp: Genetic testing for hearing loss: Where are we today?
17:00-19:00	**Poster session I**
19:00-20:30	*Dinner*
20:30-23:00	*Drinks in the poster area*

Thursday 27 August

Session 3: Hidden hearing loss: neural degeneration in “normal” hearing

08:40-09:10	Christopher Plack: Towards a diagnostic test for hidden hearing loss
09:10-09:30	Dan Goodman: Downstream changes in firing regularity following damage to the early auditory system
09:30-09:50	*Coffee break*
09:50-10:20	Kate Fernandez: If it's too loud, it's already too late
10:20-10:50	Hari Bharadwaj: Using individual differences to study the mechanisms of suprathreshold hearing deficits
10:50-11:10	*Coffee break*
11:10-11:40	Jane Bjerg Jensen: Immediate and delayed cochlear neuropathy after noise exposure in adolescent mice
11:40-12:00	Gerard Encina Llamas: Evaluation of cochlear processing and auditory nerve fiber intensity coding using auditory steady-state responses
12:00-13:30	*Lunch*

Session 4: Modelling individual hearing impairment

13:30-14:00	Enrique Lopez-Poveda: Predictors of individual hearing-aid treatment success
14:00-14:30	Michael Heinz: Neural modeling to relate individual differences in physiological and perceptual responses with sensorineural hearing loss

Thursday 27 August

Session 4: Modelling individual hearing impairment (cont.)

14:30-14:50	*Coffee break*
14:50-15:20	Volker Hohmann: Modelling temporal fine structure and envelope processing in aided and unaided hearing-impaired listeners
15:20-15:40	Josef Chalupper: Modelling individual loudness perception in CI recipients with normal contralateral hearing
15:40-16:00	Robert Baumgartner: Modelling the effect of individual hearing impairment on sound localization in sagittal planes
16:00-16:20	*Coffee break*

Session 5: Hearing rehabilitation with hearing aids and cochlear implants

16:20-16:40	Birger Kollmeier: Individual speech recognition in noise, the audiogram, and more: Using automatic speech recognition (ASR) as a modelling tool and consistency check across audiological measures
16:40-17:00	Stefan Zirn: Coding of interaural phase differences in BiCI users
17:00-19:00	**Poster Session II**
19:00-20:30	*Dinner*
20:30-23:00	*Drinks in the poster area*

Friday 28 August

Session 5: Hearing rehabilitation with hearing aids and cochlear implants (c.)

08:40-09:10	Harvey Dillon: Loss of speech perception in noise – causes and compensation
09:10-09:40	Deniz Başkent: Compensation of speech perception in hearing loss: How and to what degree can it be achieved?
09:40-10:00	*Coffee break*
10:00-10:30	Brent Edwards: Individualizing hearing aid fitting through novel diagnostics and self-fitting tools
10:30-10:50	Brian Moore: Preference for compression speed in hearing aids for speech and music and its relationship to sensitivity to temporal fine structure
10:50-11:10	Tobias Neher: Individual factors in speech recognition with binaural multi-microphone noise reduction: Measurement and prediction
11:10-11:30	*Coffee break*
11:30-11:50	Søren Laugesen: Can individualised acoustical transforms in hearing aids improve perceived sound quality?
11:50-12:10	Wouter Dreschler: A profiling system for the assessment of individual needs for rehabilitation with hearing aids based on human-related intended use (HRIU)
12:10-12:30	Torben Poulsen: Closing remarks
12:30-14:00	*Lunch and departure*

Venue and Travel Information

Venue

The symposium venue is Hotel Nyborg Strand, Østersøvej 2, 5800 Nyborg, Denmark. The hotel is situated in the middle of Denmark (GPS coordinates: Lat: N 55º 19' 5.74", Long: E 10º 48' 43.88"). The distance from Copenhagen Airport (CPH) is about 134 km, about 1½ hour by rail or road. For more information, visit www.nyborgstrand.dk. You may contact the hotel by phone (+45 65 31 31 31) or e-mail (nyborgstrand@nyborgstrand.dk).

Travel information

Air travel

The nearest airport is Copenhagen Airport "Kastrup Lufthavn" (CPH). See www.cph.dk.

From Copenhagen airport to Nyborg by rail

From the airport you will find trains directly to Nyborg. One-way standard fare: DKK 240 (approx. EUR 32, USD 35, fare may vary depending on ticket type). Direct InterCity trains leave from the airport once per hour. Duration: 1h38m. For the return journey, direct trains run every hour from Nyborg to CPH airport. More trains are available with changes. Use www.journeyplanner.dk for timetable information and www.dsb.dk/en/ for online ticket reservations.

From Copenhagen airport to Nyborg by road

Travel from CPH airport to Hotel Nyborg Strand by car takes about 1½ hour (134 km or 83 miles). Note a one-way toll charge of DKK 235 or EUR 33 per vehicle for crossing the Great Belt Bridge.

From Nyborg station to the hotel

Nyborg railway station is about a 5-minute drive from Hotel Nyborg Strand. Taxi: DKK 60 (approx. EUR 8, USD 9). If you like walking, there is a 15-minute “Nature Path” between the railway station and the hotel. Use www.journeyplanner.dk to assist your planning of local transportation.

Planning ahead

On planning your return, prepare 2 hours for transport to Copenhagen Airport and another 2 hours for check-in and security check at the airport. The scientific programme will start on August 26 at 10 am and end on August 28 at 12:30 pm. Please plan your journey accordingly.

About the weather

The weather in Denmark is unpredictable. Day temperatures between 15 and 25 degrees centigrade. Frequent showers and often windy. See www.dmi.dk for the current forecast.

Practical Information

Posters

Hanging of posters: Wed 26 Aug 08:30-10:00

Presenters of odd-numbered posters are encouraged to be present at their poster during the first dedicated poster session (Wed 17-19), presenters of even-numbered posters during the second dedicated poster session (Thu 17-19). Posters will remain on display throughout the symposium to allow further interaction outside these dedicated sessions.

Talks

Dedicated time with assistance for slide upload and technical tests in the auditorium:

Wed 26 Aug	09:00-09:30 and 17:00-17:15
Thu 27 Aug	17:00-17:15

A PC with PowerPoint software will be available in the auditorium.

Contributed oral presentations should not exceed 15 min. in length (25 min. for invited talks), in order to leave at least 5 min. after each talk for questions and discussion.

Meals and drinks

The ISAAR registration fee includes all meals and social activities during the symposium and a copy of the symposium proceedings. Two glasses of wine will be served free of charge at dinner. Complimentary beer, wine, and soft drinks will also be available in the evenings in the poster area. Other drinks may be purchased at the hotel bar.

Contact information

For any questions concerning the programme or manuscripts, please contact:
webmaster@isaar.eu

For registration or venue information, please contact Hotel Nyborg Strand directly at:
nyborgstrand@nyborgstrand.dk

For general information about ISAAR, or to contact the scientific committee, please write to:
isaar@isaar.eu

Manuscript Information

Manuscripts for ISAAR proceedings

Authors are encouraged to submit a manuscript for their ISAAR contribution. Manuscripts from both oral and poster presentations will be published in the proceedings book and distributed to all participants after the symposium. Proceedings will also be accessible to all participants via the GN ReSound audiological library (www.audiological-library.gnresound.dk).

All manuscripts must be submitted electronically at www.isaar.eu. Authors are requested to follow the manuscript guidelines and to use the templates available at www.isaar.eu. Manuscripts are limited to a maximum length of 8 pages for contributed papers and 12 pages for invited papers.

The deadline for receipt of manuscripts is 01 September 2015.

Special issue of Trends in Hearing

Authors of accepted proceedings manuscripts will be given the opportunity to submit a full journal paper based on their ISAAR contribution to a special issue of open-access journal Trends in Hearing (see http://tia.sagepub.com/).

Trends in Hearing remains the only fully open-access journal to specialize in topics related to hearing and hearing loss.

All manuscripts should be submitted by 15 November 2015. Please see the journal website for online submission and guidelines.

When submitting the manuscript, please indicate in the cover letter that the manuscript is intended for the ISAAR special issue. Overlap with material in the ISAAR book manuscript is permitted. All manuscripts will undergo peer review and authors should receive an initial decision on their manuscript by early January. We anticipate a publication date of the special issue in Spring 2016.

A special discount on publication fees will be applied for submissions to this special issue (invited papers: free; contributed papers: $525; normal publication fee: $699). In cases where funds are not available to the authors, a fee waiver may be granted.

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Session 1:

Characterizing individual differences in hearing loss

Chairs: Brian Moore and Ewen MacDonald

Wed 26 Aug, 10:10-15:00

S1.1 – Wed 26 Aug, 10:10-10:40

Characterizing individual differences: Audiometric phenotypes of age-related hearing loss

Judy R. Dubno* - *Medical University of South Carolina, Charleston, SC, USA*

A significant result from animal studies of age-related hearing loss involves the degeneration of the cochlear lateral wall, which is responsible for producing and maintaining the endocochlear potential (EP). Age-related declines in the EP systematically reduce the voltage available to the cochlear amplifier, which reduces its gain more so at higher than lower frequencies. This “metabolic presbyacusis” largely accounts for age-related threshold elevations observed in laboratory animals raised in quiet and may underlie the characteristic audiograms of older humans: a mild, flat hearing loss at lower frequencies coupled with a gradually sloping hearing loss at higher frequencies. In contrast, sensory losses resulting from ototoxic drug and noise exposures typically produce normal thresholds at lower frequencies with an abrupt transition to 50-70 dB thresholds at higher frequencies. In addition to audiograms, evidence of metabolic and sensory phenotypes in older humans can be derived from demographic information (age, gender), environmental exposures (noise and ototoxic drug histories), and suprathreshold auditory function beyond the audiogram. Once confirmed with biological markers, well-defined audiometric phenotypes of human age-related hearing loss can contribute to explanations of individual differences in auditory function for older adults. [Supported by NIH]

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S1.2 – Wed 26 Aug, 10:40-11:10

Individual differences in auditory perception among older adults with impaired hearing

Larry E. Humes* - *Indiana University, Bloomington, IN, USA*

Over the past several years, our laboratory has conducted studies of individual differences in the performance of older adults with varying degrees of hearing loss on a wide variety of auditory tasks. Typically, a range of psychophysical measures have been obtained for non-speech acoustical stimuli from relatively large samples of subjects. In addition, several studies have included measures of speech perception, especially aided and unaided speech perception in backgrounds of competing noise or speech. The most recent work on individual differences in auditory perception among older adults will be reviewed with special emphasis on two datasets: (1) one with measures of threshold sensitivity and temporal processing from 245 young, middle-age, and older adults; and (2) another with a wider range of auditory-perception measures from 98 older adults. [This work was supported, in part, by a research grant, R01 AG008293, from the National Institute on Aging.]

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S1.3 – Wed 26 Aug, 11:30-12:00

Beyond the audiogram: Influence of supra-threshold deficits associated with hearing loss and age on speech intelligibility

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Christian Lorenzi - *Laboratoire des Systèmes Perceptifs, UMR CNRS 8248, Département d'Etudes Cognitives, Institut d'Etudes de la Cognition, École Normale Supérieure, Paris, France*
Brian C. J. Moore - *Department of Experimental Psychology, University of Cambridge, Cambridge, England*
Christine Petit - *Unité de Génétique des Déficits Sensoriels, CNRS URA 1968, Institut Pasteur, Paris, France*

Sensorineural hearing loss and age are associated with poor speech intelligibility, especially in the presence of background sounds. The extent to which this is due to reduced audibility or to supra-threshold deficits is still debated. The influence of supra-threshold deficits on intelligibility was investigated for normal-hearing (NH) and hearing-impaired (HI) listeners with high-frequency losses by limiting the effect of audibility. The HI listeners were generally older than the NH listeners. Speech identification was measured using nonsense speech signals filtered into low- and mid-frequency regions, where pure-tone sensitivity was near normal for both groups. The older HI listeners showed mild to severe intelligibility deficits for speech presented in quiet and in various backgrounds (noise or speech). The intelligibility of speech in quiet and in noise was also measured for a large cohort of older NH and HI listeners, using linear amplification for listeners with mild to severe hearing losses. A measure was developed that quantified the influence of noise on intelligibility while limiting the contribution of linguistic/cognitive factors. The pure-tone average hearing loss accounted for only a third of the variability in this measure. Overall, these results suggest that speech intelligibility can be strongly influenced by supra-threshold auditory deficits.

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S1.4 – Wed 26 Aug, 13:30-14:00

Characterizing individual differences in frequency coding: Implications for hearing loss

Andrew J. Oxenham*, Kelly Whiteford - *University of Minnesota, Minneapolis, MN, USA*

Our ability to perceive changes in frequency or pitch is remarkably accurate. This high sensitivity, along with its degradation at high frequencies, has led to analogies with the exquisite sensitivity to interaural time differences (ITDs) and to the proposal that phase-locking in the auditory nerve is used to code frequency. Here we use individual differences between normal-hearing listeners in an attempt to tease apart different contributions to frequency perception. We tested 100 listeners in frequency-modulation (FM) detection at low and high rates, thought to be mediated by phase-locking and place cues, respectively, along with amplitude-modulation (AM) detection, binaural (time and level) disparity detection, and frequency selectivity, all around a frequency of 500 Hz. Strong correlations were found between FM and ITD detection, in apparent support of the timing hypothesis. However, equally strong correlations were found between these measures and other measures, such as AM detection, which are not thought to rely on phase-locking. Information about frequency selectivity did not improve the predictions of either fast or slow FM. The results suggest that FM detection in normal hearing is limited neither by peripheral phase-locking nor by peripheral frequency selectivity. Alternative modeling approaches using cortical noise correlations are considered.

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S1.5 – Wed 26 Aug, 14:00-14:20

Interrelations between ABR and EFR measures and their diagnostic power in targeting subcomponents of hearing loss

Sarah Verhulst*, Anoop Jagadeesh - *Department of Medical Physics, Oldenburg University, Oldenburg, Germany*

Given the recent classification of sensorineural hearing loss in outer-hair-cell loss and a temporal coding deficit due to auditory-nerve fiber loss, this study evaluated how brainstem response measures can be more effectively used in the diagnostics of subcomponents of hearing loss. We studied the relationship between auditory-brainstem (ABR) and envelope-following response (EFR) measures, and how they relate to threshold and compression (DPOAE) measures in 32 listeners with normal to mild hearing losses. The relationships between the resulting click ABR wave-I and V level-series and EFRs to 75-dB-SPL broadband noise of different modulation depths indicate that the EFR strength-vs-modulation-depth-reduction and ABR measures are likely to inform about different aspects of hearing loss. Because ABR latency and strength correlated with each other, and the ABR latency-vs-level slope with hearing thresholds, we suggest that cochlear spread of excitation, and to a lesser extent neuropathy, is responsible for differences in ABR measures across listeners. The EFR slope measure did not correlate with any other metric tested and might reflect temporal coding aspects of hearing irrespective of the degree of cochlear excitation (or outer-hair-cell loss). We are further strengthening this hypothesis using a human ABR model in which the subcomponents of hearing loss can be controlled.

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S1.6 – Wed 26 Aug, 14:20-14:40

Is cochlear gain reduction related to speech-in-babble performance?

Kristina DeRoy Milvae [*,S], ***Joshua M. Alexander, Elizabeth A. Strickland*** -
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Noisy settings are difficult listening environments. With some effort, individuals with normal hearing are able to overcome this difficulty when perceiving speech, but the auditory mechanisms that help accomplish this are not well understood. One proposed mechanism is the medial olivocochlear reflex (MOCR), which reduces cochlear gain in response to sound. It is theorized that the MOCR could improve intelligibility by applying more gain reduction to the noise than to the speech, thereby enhancing the internal signal-to-noise ratio. To test this hypothesized relationship, the following measures were obtained from listeners with normal hearing. Cochlear gain reduction was estimated psychoacoustically using a forward masking task. Speech-in-noise recognition was assessed using the QuickSIN test (Etymotic Research), which generates an estimate of the speech reception threshold (SRT) in background babble. Results were surprising because large reductions in cochlear gain were associated with large SRTs, which was the opposite of the hypothesized relationship. In addition, there was a large range for both cochlear gain reduction and SRT across listeners, with many individuals falling outside of the normal SRT range despite having normal-hearing thresholds. Interpretation of these results will be discussed.

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S1.7 – Wed 26 Aug, 14:40-15:00

Effects of cochlear compression and frequency selectivity on pitch discrimination of unresolved complex tones

Federica Bianchi*, Johannes Zaar, Michal Fereczkowski, Sébastien Santurette, Torsten Dau - *Hearing Systems, Department of Electrical Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark*

Physiological studies have shown that noise-induced sensorineural hearing loss (SNHL) enhances the amplitude of envelope coding in auditory-nerve fibers. As pitch coding of unresolved complex tones is assumed to rely on temporal envelope coding mechanisms, this study investigated pitch-discrimination performance in listeners with SNHL. Pitch-discrimination thresholds were obtained in 14 normal-hearing (NH) and 10 hearing-impaired (HI) listeners for sine-phase (SP) and random-phase (RP) unresolved complex tones. Eight HI listeners performed at least as well as NH listeners in the SP condition. In the RP condition, seven HI listeners performed worse than NH listeners. Cochlear compression estimates obtained in the same HI listeners were negatively correlated with the difference in pitch-discrimination thresholds between the two phase conditions. The effects of degraded frequency selectivity and loss of compression were considered in a model as potential factors in envelope enhancement. The model revealed that a broadening of the auditory filters led to an increase of the modulation power at the output of the filters in the SP condition and to a decrease for the RP condition. Overall, these findings suggest that HI listeners benefit from enhanced temporal envelope coding regarding pitch discrimination of unresolved complex tones.

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Session 2:

Genetics of hearing loss

Chairs: Lisbeth Tranebjærg and Jakob Christensen-Dalsgaard

Wed 26 Aug, 15:30-17:00

S2.1 – Wed 26 Aug, 15:30-16:00

What mouse mutants tell us about deafness

Karen P. Steel* *- King's College London, London, England*

Progressive hearing loss is very common in the human population and can start at any age from the first decade of life onwards. Single gene mutations have been implicated in progressive hearing loss in a handful of extended families where linkage analysis can be used to pinpoint the causative mutations, but for most cases there are no clues to the causes. It is likely that a combination of environmental factors and genetic predisposition underlies hearing loss in many cases, making it difficult to study directly. Mouse mutants offer an alternative approach to identifying genes that are essential for maintenance of normal hearing. We have generated a large number of new mouse mutants with known genes inactivated and screened them for hearing deficits by auditory brainstem response recording (ABR) at 14 weeks old. Out of the first 900 new mutant lines screened, 25 new genes not previously suspected of involvement in deafness have shown raised thresholds. Several of these have been followed up with ABR at different ages and show progressive increases in thresholds with age. Examples of primary defects in the hair cells, in synapses below inner hair cells, and in maintenance of endocochlear potential have been discovered, emphasising the heterogeneous nature of progressive hearing loss. These genes represent good candidates for involvement in human progressive hearing loss.

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S2.2 – Wed 26 Aug, 16:00-16:30

Genetic defects and their impact on auditory function

Hannie Kremer* *- Hearing & Genes, Department of Otorhinolaryngology and Department of Human Genetics, Radboud University Medical Center, Nijmegen, The Netherlands*

Defects in more than 100 genes can underlie hearing loss. For congenital or early childhood hearing impairment, genetic causes are estimated to account for about half of the cases. Age-related hearing loss is the result of an interplay between many different genetic and environmental factors in an individual. For hearing impairment with an onset between early childhood and ageing, the relative importance of genetic and environmental causes is not well known. Defects in a large subset of deafness genes affect hair-cell function (a.o., mechanotransduction) but also other processes such as development of the endocochlear potential can be affected in hereditary deafness. Identification of deafness genes has contributed to our understanding of cochlear function at the molecular level. Importantly, correlations have been unveiled between genetic defects and the auditory phenotype in pure-tone audiograms and, more recently, psychophysical characteristics. Therefore, etiological studies including genetic diagnostics after failure in neonatal hearing screening are not only important for genetic counseling of families but can provide important information on prognosis and rehabilitation. Furthermore, a genetic diagnosis can uncover the hearing impairment to be part of a syndrome (e.g., Usher syndrome) and early monitoring or intervention can be initiated for associated medical problems.

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S2.3 – Wed 26 Aug, 16:30-17:00

Genetic testing for hearing loss: Where are we today?

Guy Van Camp* - *Medical Genetics, University of Antwerp, Antwerp, Belgium*

Hearing loss is the most common sensorial disorder in children, with an incidence of 1 in 500 newborns. Most cases are caused by mutations in a single gene. However, DNA diagnostics for hearing loss are challenging, since it is an extremely heterogeneous trait. Although more than 50 causative genes have been identified for the nonsyndromic forms of hearing loss alone, diagnostic application of the scientific progress has lagged behind. The reason for this is the cost: Screening all the known causatives genes for hearing loss in one patient with the current golden standard for DNA diagnostics, Sanger sequencing, would be extremely expensive. Consequently, current routine DNA diagnostic testing for hearing loss is restricted to one or two of the most common causative genes, which identifies the responsible gene in only 10-20% of cases. Recently several reports have shown that “next generation DNA sequencing techniques” allow the simultaneous analysis of panels consisting of 50 or more deafness genes at a reasonable cost. In addition, whole exome sequencing techniques offer the possibility to analyze all human genes, and get a genetic diagnosis even for genes not present in these gene panels. It is to be expected that these new tests will greatly improve DNA diagnostics over the next years.

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Session 3:

Hidden hearing loss: Neural degeneration in "normal" hearing

Chairs: Deniz Başkent and Andrew Oxenham

Thu 27 Aug, 08:40-12:00

S3.1 – Thu 27 Aug, 08:40-09:10

Towards a diagnostic test for hidden hearing loss

***Christopher J. Plack*, Garreth Prendergast, Karolina Kluk, Agnès Léger, Hannah Guest, Kevin J. Munro** - The University of Manchester, Manchester Academic Health Science Centre, Manchester, England*

Cochlear synaptopathy, due to noise exposure or ageing, has been demonstrated in animal models using histological techniques. However, diagnosis of the condition in individual humans is problematic. Wave I of the transient-evoked auditory brainstem response (ABR) is a non-invasive electrophysiological measure of auditory nerve function, and has been validated in the animal models. However, in humans wave I amplitude shows high variability both between and within individuals. The frequency-following response (FFR), a sustained evoked potential reflecting synchronous neural activity in the rostral brainstem, is potentially more robust than ABR wave I. However, the FFR is a measure of central activity, and may be dependent on individual differences in central processing. Psychophysical measures are also affected by inter-subject variability in central processing. Differential measures, in which the measure is compared, within an individual, between conditions that are affected differently by cochlear synaptopathy, may help to reduce inter-subject variability due to unrelated factors. There is also the issue of how the metric will be validated. Comparisons with animal models, computational modelling, human temporal bone histology, and auditory nerve imaging are all potential options for validation, but there are technical and practical hurdles, and difficulties in interpretation.

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S3.2 – Thu 27 Aug, 09:10-09:30

Downstream changes in firing regularity following damage to the early auditory system

Dan F. M. Goodman* - *Imperial College, London, England*
Alain de Cheveigné - *Ecole Normale Supérieure, Paris, France*
Ian M. Winter - *University of Cambridge, Cambridge, England*
Christian Lorenzi - *Ecole Normale Supérieure, Paris, France*

We use an abstract mathematical model that approximates a wide range of more detailed models to make predictions about hearing loss-related changes in neural behaviour. One consequence of neurosensory hearing loss is a reduced ability to understand speech, particularly in noisy environments, which may go beyond what would be predicted from reduced audibility. Experimental results in mice showing that there can be a permanent loss of auditory nerve fibres following "temporary" noise-induced hearing loss are promising, but the downstream consequences of this loss of fibres has not yet been systematically investigated. We approximate the stationary behaviour of chopper cells in the cochlear nucleus with a stochastic process that is entirely characterised by its mean, standard deviation, and time constants. From this we predict that the classification of choppers as transient or sustained will be level-dependent, and we verify this with experimental data. We also predict that chopper regularity will decrease following deafferentation, causing sustained choppers to behave as transients. While the function of choppers is still debated, one suggestion is the coding of temporal envelope, widely agreed to be essential for understanding speech. Deafferentation could therefore lead to a disruption of the processing of temporal envelope, and consequently degrade speech intelligibility.

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S3.3 – Thu 27 Aug, 09:50-10:20

If it's too loud, it's already too late

Katharine Fernandez*, Sharon Kujawa *- Massachusetts Eye and Ear Infirmary, Boston, MA, USA*

The earliest sign of damage in hearing losses due to noise and aging is cochlear synaptic loss. We evaluated two types of noise exposure: one that produces permanent damage to the inner hair cell-afferent nerve synapse without hair cell loss and another that produces no synaptopathy or hair cell death. Adult mice were exposed for 2 hours using an 8-16kHz OBN at either 91 or 100 dB SPL. Cochlear function was assessed via distortion product otoacoustic emission (DPOAE) and auditory brainstem responses (ABRs) from 1 h to 20 months post exposure. Whole mounted tissues and plastic sections were examined to quantify hair cells and cochlear neurons. Our 100 dB SPL synaptopathic noise elicited a robust, but reversible, threshold shift; however suprathreshold ABR amplitudes and cochlear synapses at high frequencies were permanently reduced by up to 45%. With age, synaptopathy was exacerbated compared to age-matched controls and the area of damage spread to include previously unaffected lower frequencies. In contrast, the 91 dB exposure produced a robust temporary threshold shift but without acute synaptopathy. In animals aged to 1 year post exposure, no signs of accelerated synaptic loss or cochlear dysfunction were evident. We conclude that there is an interaction between noise and aging that is largely influenced by acute synaptopathy.

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S3.4 – Thu 27 Aug, 10:20-10:50

Using individual differences to study the mechanisms of suprathreshold hearing deficits

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Inyong Choi, Barbara G. Shinn-Cunningham - *Boston University, Boston, MA, USA*

About one in ten adults complaining of difficulty communicating in noisy settings turn out to have "normal hearing" (NH). In the laboratory, NH listeners from the general population exhibit large individual differences in suprathreshold perceptual ability. Here, we present a series of experiments using otoacoustic emissions, electrophysiology, and neuroimaging that seek to reveal the mechanisms that influence individual differences in performance in suprathreshold listening tasks. We find that both subcortical temporal coding and cortical oscillatory signatures of active listening independently correlate with performance. Interpreted in conjunction with animal models of neural degeneration in acoustic overexposure and aging, our results suggest that one factor contributing to performance differences among NH listeners arises from hidden hearing deficits likely originating at the level of the cochlear nerve. Further, our results show that cortical signatures of active listening may help explain why some listeners with good subcortical coding still perform poorly. Finally, we comment on the roles of subcortical feedback circuits (olivocochlear efferents and middle-ear muscle reflexes) and individual differences in anatomical factors in the the interpretation of electrophysiological measures and the diagnosis of hidden hearing damage.

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S3.5 – Thu 27 Aug, 11:10-11:40

Immediate and delayed cochlear neuropathy after noise exposure in adolescent mice

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Konstantina Stankovic *- Massachusetts Eye and Ear Infirmary, Eaton Peabody Lab., Boston, USA; Department of Otology and Laryngology, Harvard Medical School, Boston, USA; Program in Speech and Hearing Bioscience and Technology, Division of Health Science and Technology, Harvard and Massachusetts Institute of Technology, Boston, USA*

Our objective was to determine whether a cochlear synaptopathy, followed by neuropathy, occurs after noise exposure that causes temporary threshold shift (TTS) in adolescent mice, and to explore differences in molecular networks. Exposing 6 weeks old CBA/CaJ mice to 8-16 kHz bandpass noise for 2 hours, we defined 97 dB sound pressure level (SPL) as the threshold for neuropathic noise associated with TTS, and 94 dB SPL as the highest non-neuropathic noise level associated with TTS. Mice exposed to neuropathic noise demonstrated immediate cochlear synaptopathy and delayed neurodegenerative neuronal loss. To gain insight into molecular mechanisms that may underlie TTS, we performed network analysis (Ingenuity® Pathway Analysis) of genes and proteins reported to be involved in noise-induced TTS. The analysis revealed 6 significant molecular networks, and one was new to the inner ear: Hepatocyte Nuclear Factor 4 alpha (HNF4α). We characterized Hnf4α expression in the murine cochlea from 6 weeks to 18 months of age, and discovered that Hnf4α expression decreased 16 months after exposure to neuropathic noise. We localized Hnf4α expression to spiral ganglion neurons and cochlear supporting cells. Our data contribute to the mounting evidence of cochlear neuropathy underlying “hidden” hearing loss and points to a novel orchestrator from the steroid receptor superfamily.

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S3.6 – Thu 27 Aug, 11:40-12:00

Evaluation of cochlear processing and auditory nerve fiber intensity coding using auditory steady-state responses

Gerard Encina Llamas*, Bastian Epp - *Hearing Systems, Department of Electrical Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark*
James Michael Harte - *Interacoustics Research Unit, Kgs. Lyngby, Denmark*
Torsten Dau - *Hearing Systems, Department of Electrical Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark*

The compressive nonlinearity of the auditory system is assumed to be an epiphenomenon of a healthy cochlea and particularly outer-hair cell function. Auditory steady-state responses (ASSR) reflect coding of the stimulus envelope. Recent research in animals shows that noise over-exposure, producing temporary threshold shifts, can cause auditory nerve fiber (ANF) deafferentation in predominantly low-spontaneous rate (SR) fibers. It is hypothesized here that deafferentation of low-SR fibers can lead to a reduction of ASSR amplitude at supra-threshold levels. ASSR input/output (I/O) functions were measured in two groups of normal-hearing adults at stimulus levels ranging from 20 to 90 dB SPL. First, multi-frequency ASSR I/O functions were obtained using a modulation depth of 85%. Secondly, ASSR were obtained using a single sinusoidally amplitude modulated (SAM) tone at four modulation depths (25, 50, 85, and 100%). Results showed that ASSR growth functions exhibit compression of about 0.25 dB/dB. The slope for levels above 60 dB SPL showed more variability across subjects. The slope of ASSR I/O functions could be used to estimate peripheral compression simultaneously at four frequencies below 60 dB SPL, while the slope above 60 dB SPL might be used to evaluate the integrity of intensity coding of low-SR fibers.

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Session 4:

Modelling individual hearing impairment

Chairs: Birger Kollmeier and Torsten Dau

Thu 27 Aug, 13:30-16:00

S4.1 – Thu 27 Aug, 13:30-14:00

Predictors of individual hearing-aid treatment success

Enrique A. Lopez-Poveda*, Peter T. Johannesen, Patricia Pérez-González - *University of Salamanca, Salamanca, Spain*
William S. Woods, Sridhar Kalluri - *Starkey Hearing Research Center, Berkeley, CA, USA*
José L. Blanco - *University of Salamanca, Salamanca, Spain*
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Hearing aid (HA) users report large differences in their level of satisfaction as well as in their level of performance with their HAs, and the reasons are still uncertain. We aimed at predicting HA treatment success from a linear combination of demographic variables, HA settings, behavioral and physiological estimates of cochlear mechanical dysfunction, behavioral estimates of auditory temporal processing abilities, and a measure of cognitive function. HA treatment success was assessed objectively using the speech reception threshold in noise, and subjectively using various standardized questionnaires. Success measures and predictors were obtained in 68 HA users with bilateral, symmetric, sensorineural hearing loss. Stepwise, multiple linear regression was used to design predictive models of treatment success as well as to assess the relative importance of the predictors. The results suggest that once the HA gain is sufficient for both the speech and the noise to be above the audibility threshold, temporal processing ability is the most important predictor of speech-in-noise intelligibility; other variables (e.g., cochlear mechanical dysfunction, HA settings, or cognitive status) did not emerge as significant predictors. Subjectively assessed success was only weakly correlated with cognitive abilities and it could not be predicted based on the present set of predictors.

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S4.2 – Thu 27 Aug, 14:00-14:30

Neural modeling to relate individual differences in physiological and perceptual responses with sensorineural hearing loss

Michael G. Heinz* *- Purdue University, West Lafayette, IN, USA*

A great challenge in diagnosing and treating hearing impairment comes from the fact that people with similar degrees of hearing loss often have different speech-recognition abilities. Many studies of the perceptual consequences of peripheral damage have focused on outer-hair-cell (OHC) effects; however, anatomical and physiological studies suggest that many common forms of sensorineural hearing loss (SNHL) arise from mixed OHC and inner-hair-cell (IHC) dysfunction. Thus, individual differences in perceptual consequences of hearing impairment may be better explained by a more detailed understanding of differential effects of OHC/IHC dysfunction on neural coding of perceptually relevant sounds. Whereas it is difficult experimentally to estimate or control the degree of OHC/IHC dysfunction in individual subjects, computational neural models provide great potential for predicting systematically the complicated physiological effects of combined OHC/IHC dysfunction. This presentation will review important physiological effects in auditory-nerve (AN) responses following different types of SNHL and the ability of current AN models to capture these effects. In addition, the potential for quantitative spike-train metrics of temporal AN coding to provide insight towards relating these differential physiological effects to differences in speech intelligibility will be discussed.

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S4.3 – Thu 27 Aug, 14:50-15:20

Modeling temporal fine-structure and envelope processing in aided and unaided hearing-impaired listeners

Stephan D. Ewert, Steffen Kortlang, Volker Hohmann* - *Medizinische Physik/Cluster of Excellence Hearing4All, Universität Oldenburg, Oldenburg, Germany*

Sensorineural hearing loss typically manifests in elevated thresholds and loudness recruitment mainly related to outer hair cell (OHC) damage. However, if these factors are partly compensated for by dynamic range compression in hearing aids, temporal coding deficits might persist affecting temporal fine structure (TFS) and amplitude modulation (AM) processing. Moreover, such temporal coding deficits might already exist in elderly listeners with unremarkable audiometric thresholds as “hidden” hearing loss, likely caused by damage of inner hair cells (IHC) and/or subsequent stages. In individual hearing-impaired (HI) listeners, both OHC and IHC damage might affect perception to a different degree. To assess the consequences and relative role of both, a simple functional model is proposed which mimics coding of TFS and AM features based on simulated probabilistic auditory nerve responses. The model combines two possible detection mechanisms based on phase-locking and AM. OHC and IHC damage were incorporated and adapted to predict frequency modulation discrimination and discrimination of phase-jittered sweeps in elderly normal-hearing and in HI listeners. The role of external noise present in the stimulus itself and internal noise as a consequence of temporal coding deficits are assessed for processing of speech signals using dynamic compression and noise reduction algorithms.

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S4.4 – Thu 27 Aug, 15:20-15:40

Modelling individual loudness perception in CI recipients with normal contralateral hearing

Josef Chalupper*, Stefan Fredelake - *Advanced Bionics, European Research Center, Hannover, Germany*

For users of cochlear implants (CI) with close to normal hearing on the contralateral side, a thorough balancing of loudness across ears potentially improves localization and spatial release from masking. Adjusting the fitting parameters of the CI, however, can be a tedious process as individual electric loudness perception is affected by a multitude of specific parameters of electric stimulation, e.g., amplitude of current, pulse rate, pulse width, number and interaction of electrodes and inter-phase gap. Theoretically, psychoacoustic loudness models could help to reduce the effort for loudness balancing in clinical practice. In contrast to acoustic hearing, however, loudness models for electric hearing are not used frequently, neither in research nor in clinical practice. In this study, the "practical" loudness model by McKay and McDermott was used to simulate behavioral data for electric hearing and the "Dynamic Loudness Model" [Chalupper and Fastl, 2002] for acoustic hearing. Analogous to modeling acoustic loudness of individual hearing-impaired listeners, the transformation from excitation (here: current) to specific loudness needs to be adjusted individually. For some patients, model calculations show deviations from behavioral data. In addition to loudness growth, information on electric field overlap between electrodes is required to predict individual electric loudness.

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S4.5 – Thu 27 Aug, 15:40-16:00

Modeling the effect of individual hearing impairment on sound localization in sagittal planes

Robert Baumgartner,S, **Piotr Majdak, Bernhard Laback*** - *Acoustics Research Institute, Austrian Academy of Sciences, Vienna, Austria*

Normal-hearing (NH) listeners use monaural spectral cues to localize sound sources in sagittal planes, including up-down and front-back directions. The salience of monaural spectral cues is determined by the spectral resolution and the dynamic range of the auditory system. Both factors are commonly degraded in impaired auditory systems. In order to simulate the effects of outer hair cell (OHC) dysfunction and loss of auditory nerve (AN) fibers on localization performance, we incorporated a well-established model of the auditory periphery [Zilany et al., 2014, JASA 135] into a recent model of sound localization in sagittal planes [Baumgartner et al., 2014, JASA 136]. The model was evaluated for NH listeners and then applied on conditions simulating various degrees of OHC dysfunction. The predicted localization performance significantly degraded with increasing OHC dysfunction and approached chance performance in the condition of complete OHC loss. When further applied on conditions simulating losses of AN fibers with specific spontaneous rates (SRs), predicted localization performance for moderately loud sounds depended much more on the survival of low- or medium-SR fibers than of the more frequent high-SR fibers. This result is particularly important given the recent finding that noise-induced cochlear neuropathy seems to be selective for fibers with low and medium SRs.

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Session 5:

Individualized diagnostics and compensation strategies

Chairs: Karolina Smeds and Jeremy Marozeau

Thu 27 Aug, 16:20-17:00
Fri 28 Aug, 08:40-12:10

S5.1 – Thu 27 Aug, 16:20-16:40

Individual speech recognition in noise, the audiogram, and more: Using automatic speech recognition (ASR) as a modelling tool and consistency check across audiological measures

Birger Kollmeier*, Marc René Schädler, Anna Warzybok, Bernd T. Meyer, Thomas Brand *- Medizinische Physik and Cluster of Excellence Hearing4all, Universität Oldenburg, Oldenburg, Germany*

How well do the various audiological findings fit together and how can this information be used to characterize the individual hearing problem of each patient – preferably in a way which is independent from his or her native language? A procedure to find solutions for this fundamental diagnostic problem in rehabilitative audiology is proposed and discussed: It builds on the closed-set Matrix sentence recognition test which is advantageous for testing individual speech recognition in a way comparable across languages [review by Kollmeier et al., 2015, Int. J. Audiol. online first]. The results can be predicted by an individually adapted, reference-free ASR system which utilizes the limited vocabulary of the Matrix test and its fixed syntactic structure for training and yields a high prediction accuracy for normal listeners across certain noise conditions [Schädler et al., submitted]. The same setup can be used to predict a range of psychoacoustical experiments and to evaluate the required individual settings of the physiologically and psychoacoustically motivated front end of the recognizer to account for the individual hearing impairment. Hence, a minimum set of assumptions and individual audiological parameters may be used to characterize the individual patient and to check the consistency across his or her available audiological data in a way comparable across languages.

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S5.2 – Thu 27 Aug, 16:40-17:00

Coding of interaural phase differences in BiCI users

Stefan Zirn*, Susan Arndt, Thomas Wesarg - *Department of Oto-Rhino-Laryngology of the Medical Center, University of Freiburg, Freiburg, Germany*

The ability to detect a signal masked by noise is improved in normal-hearing (NH) listeners when interaural phase differences (IPD) between the ear signals exist either in the masker or the signal. We determined the impact of different coding strategies in bilaterally implanted cochlear implant (BiCI) users with and without fine-structure coding (FSC) on masking level differences. First, binaural intelligibility level differences (BILD) were determined in NH listeners and BiCI users using their clinical speech processors. NH subjects (n=8) showed a significant BILD of 7.5 ± 1.3 dB**. In contrast, BiCI users (n=7) without FSC (HDCIS) revealed no significant BILD (0.4 ± 0.6 dB) and with FSC (FS4) a barely significant BILD (0.6 ± 0.9 dB). Second, IPD thresholds were measured in BiCI users using either their speech processors with FS4 or direct stimulation with FSC. With the latter approach, synchronized stimulation providing an interaural accuracy of stimulation timing of 1.67 μs was realized on pitch-matched electrode pairs. The resulting individual IPD threshold was lower in most of the subjects with direct stimulation than with their speech processors. These outcomes indicate that some BiCI users can benefit from increased temporal precision of interaural FSC and adjusted interaural frequency-place mapping presumably resulting in improved BILD.

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S5.3 – Fri 28 Aug, 08:40-09:10

Loss of speech perception in noise – Causes and compensation

Harvey Dillon*, Elizabeth Beach, Ingrid Yeend, Helen Glyde - *NAL, The HEARing CRC, Sydney, Australia*
Jörg Buchholz - *NAL, Macquarie University, The HEARing CRC, Sydney, Australia*
Jorge Mejia, Tim Beechey, Joaquin Valderrama - *NAL, The HEARing CRC, Sydney, Australia*
Mridula Sharma - *Macquarie University, The HEARing CRC, Sydney, Australia*

This paper reports on two of the probably many reasons why hearing-impaired people need better signal-to-noise ratios (SNRs) than others to communicate in background noise, and shows the effectiveness of beamforming in addressing this deficit. The first reason is inaudibility of high-frequency sounds, even when aided, as these sounds have the largest head diffraction effects, which are the key to enabling better-ear glimpsing, which most facilitates speech understanding in spatialized noise. The second (probable) reason is reduced resolution arising from noise damaging high-level nerve fibres. Early data from a comprehensive experiment examining this behaviourally and electrophysiologically will be presented. Wireless remote microphones most improve SNR, but cannot always be used. Next best are super-directional binaural beamformers. These improve performance over conventional directional microphones by 1 to 5 dB improvement in speech reception threshold in noise (SRTn). The presentation will show how the degree of improvement depends on the manner of evaluation. Evaluations performed at SNRs typical of realistic listening conditions, whether based on perceived quality, change in acceptable background noise level, or change in SRTn, are greater than when SRTn is evaluated at very negative SNRs.

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S5.4 – Fri 28 Aug, 09:10-09:40

Compensation of speech perception in hearing loss: How and to what degree can it be achieved?

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Anastasios Sarampalis - *University of Groningen, Department of Psychology, Groningen, The Netherlands*
Anita Wagner, Etienne Gaudrain - *University of Groningen, University Medical Center Groningen, Groningen, The Netherlands*

Perception of speech that is degraded due to environmental factors, such as background noise or poor room acoustics, can be enhanced using cognitive mechanisms. Two such mechanisms are the top-down perceptual restoration of degraded speech using cognitive and linguistic resources, namely phonemic restoration, and increasing cognitive resources needed for speech comprehension, namely listening effort. Reduced audibility and sound quality caused by hearing loss, similar to external factors, negatively affect speech intelligibility. However, it is not very clear if hearing-impaired individuals and hearing-device users can as successfully use the cognitive compensation mechanisms, due to the interactive effects of internal and external speech degrading factors, aging, and hearing device front-end processing. Our recent research has shown that degradations due to hearing loss or due to external factors can be compensated. However, when the two are combined, the benefits of top-down compensation can be limited. Front-end processing and aging can also influence the compensation, but not always in a predictable manner. These findings indicate that new methods need to be incorporated into audiological practices and device development procedures to capture such complex and interactive effects of cognitive factors in speech perception with hearing loss.

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S5.5 – Fri 28 Aug, 10:00-10:30

Individualizing hearing aid fitting through novel diagnostics and self-fitting tools

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The audiogram has long been considered a poor representation of a person's hearing impairment, as evidenced by the poor predictive capability that the audiogram has towards hearing aid benefit. Preference for the setting of sophisticated hearing aid features such as frequency lowering and noise reduction can depend on many factors, making the audiologist's job of fitting these features to individual patients difficult. Novel diagnostics and outcome measures have been developed to aid with compensation strategies, including approaches that are regulated by the patient. Wireless integration of hearing aids with smartphones allows for these approaches to take place outside of the clinic and in the patient's real-world experience, helping individualize the treatment for their hearing loss. This talk will review these developments and their potential effect on the future role of hearing healthcare professionals in the provision of hearing aid technology.

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S5.6 – Fri 28 Aug, 10:30-10:50

Preference for compression speed in hearing aids for speech and music and its relationship to sensitivity to temporal fine structure

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Aleksander Sęk *- Institute of Acoustics, Adam Mickiewicz University, Poznań, Poland*

Multi-channel amplitude compression is widely used in hearing aids. The preferred compression speed varies across individuals. Moore [2008, Trends Amplif. 12, 300-315] suggested that reduced sensitivity to temporal fine structure (TFS) may be associated with preference for slow compression. This idea was tested using a simulated hearing aid. It was also assessed whether preferences for compression speed depend on the type of stimulus: speech or music. Eighteen hearing-impaired subjects were tested, and the stimulated hearing aid was fitted individually using the CAM2 method. On each trial a given segment of speech or music was presented twice. One segment was processed with fast compression and the other with slow compression, and the order was balanced across trials. The subject indicated which segment was preferred and by how much. On average, slow compression was preferred over fast compression, more so for music, but there were distinct individual differences, which were highly correlated for speech and music. Sensitivity to TFS was assessed using the difference limen for frequency at 2 kHz and by two measures of sensitivity to interaural phase at low frequencies. The results for the DLFs, but not the measures of sensitivity to interaural phase, provided some support for the suggestion that preference for compression speed is affected by sensitivity to TFS.

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S5.7 – Fri 28 Aug, 10:50-11:10

Individual factors in speech recognition with binaural multi-microphone noise reduction: Measurement and prediction

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Daniel Marquardt *- Signal Processing Group and Cluster of Excellence Hearing4all, Oldenburg University, Oldenburg, Germany*
Thomas Brand *- Medizinische Physik and Cluster of Excellence Hearing4all, Oldenburg University, Oldenburg, Germany*

Multi-microphone noise reduction algorithms typically produce large signal-to-noise ratio (SNR) improvements, but they can also severely distort binaural information and thus compromise spatial hearing abilities. To address this problem Klasen et al. [2007, IEEE Trans. Signal Process.] proposed an extension of the binaural multi-channel Wiener filter (MWF), which suppresses only part of the noise and in this way preserves some binaural information (MWF-N). The current study had three aims: (1) to assess aided speech recognition with MWF and MWF-N for a group of hearing-impaired listeners, (2) to explore the impact of individual factors on their performance, and (3) to test if a binaural speech intelligibility model [Beutelmann and Brand, 2010, JASA] can predict outcome. Sixteen elderly hearing aid users took part. Speech recognition was assessed using headphone simulations of a spatially complex speech-in-noise scenario. Individual factors were assessed using audiometric, psychoacoustic (binaural), and cognitive measures. Analyses showed clear benefits from MWF and MWF-N, and also suggested sensory and binaural influences on speech recognition. Model predictions were reasonably accurate for MWF but not MWF-N, suggesting a need for some model refinement concerning binaural processing abilities.

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S5.8 – Fri 28 Aug, 11:30-11:50

Can individualised acoustical transforms in hearing aids improve perceived sound quality?

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All ears are acoustically different, but nevertheless most hearing aids are fitted using average acoustical transforms (open ear gain, real ear to coupler difference, and microphone location effect). This paper presents an experiment which aimed to clarify whether benefits in terms of perceived sound quality can be obtained from fitting hearing aids according to individualised acoustical transforms instead of average transforms. 18 normal-hearing test subjects participated, and hearing-aid sound processing with various degrees of individualisation was simulated and applied to five different sound samples, which were presented over insert phones in an A/B test paradigm. Data were analysed with the Bradley-Terry-Luce model. The key result was that individualised acoustical transforms measured in the “best-possible” way in a laboratory setting were preferred over average transforms. This result confirms the hypothesized sound-quality benefit of individualised over average transforms, while there was some variation across test subjects and sound samples. In addition, it was found that representing the individualised transforms in lower frequency resolution was preferred over the representation in fine spectral detail. The analysis suggests that this may be because of an artefact of the low-resolution representation which added a slight boost in the 6-8 kHz frequency range.

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S5.9 – Fri 28 Aug, 11:50-12:10

A profiling system for the assessment of individual needs for rehabilitation with hearing aids, based on human-related intended use (HRIU)

Wouter A. Dreschler*, Inge Brons - *Department of Clinical & Experimental Audiology, AMC, Amsterdam, The Netherlands*

A new profiling system has been developed for the reimbursement of hearing aids, based on individual profiles of compensation needs. The objective is to provide an adequate solution: a simple hearing aid when possible and a more complex aid when necessary. For this purpose we designed a model to estimate user profiles for human-related intended use (HRIU). HRIU is based on self-report data: a modified version of the AIADH, combined with a COSI-approach. AVAB results determine the profile of disability and COSI results determine the profile of targets. The difference between these profiles can be interpreted as the profile of compensation needs: the HRIU profile. This approach yields an individual HRIU profile with scores on six dimensions: detection, speech in quiet, speech in noise, localization, focus, and noise tolerance. The HRIU-profile is a potential means to determine the degree of complexity and/or sophistication of the hearing aid needed, that can be characterized by a product-related intended use profile (PRIU). Post-fitting results show improvements in the 6 dimensions and determine whether the hearing aid is adequate. Also it provides well-standardized data to evaluate the basic assumptions and to improve the system based on practice-based evidence. This new approach will be highlighted and some first results will be presented.

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Poster Sessions I and II

Posters will remain on display throughout the symposium.

Presenters will be at their posters:

Wed 26 Aug, 17:00-19:00 (odd-numbered posters)
Thu 27 Aug, 17:00-19:00 (even-numbered posters)

P.1 – Wed 26 Aug, 17:00-19:00

Influences of chronic alcohol intake on hearing recovery of CBA mice from temporary noise-induced threshold shift

Joong Ho Ahn*, Myung Hoon Yoo - *Department of Otolaryngology, Asan Medical Center, University of Ulsan College of Medicine, Ulsan, South Korea*

Objective: To investigate the effects of chronic alcohol intake on hearing recovery of CBA mice from noise-induced temporary threshold shift (TTS). *Methods and Materials:* We divided CBA mice with normal hearing into 2 groups: control (n=6), 1 g/kg alcohol group (n=13). In the alcohol group, ethanol was administrated intragastrically via feeding tube daily for 3 months. In the control group, normal saline was administrated for 3 months. TTS was induced by 1-hour exposure to 110 dB broad-band noise. Hearing thresholds were checked with click ABR before noise exposure, just after exposure, and 1, 3, 5, 7, 14 days after exposure. Anatomical findings with immunohistochemical study and western blots for HIF1-ɑ were also evaluated. *Results:* In the alcohol group, average hearing thresholds were significantly higher than in the control group after 3 months before noise exposure at 4, 8, 16 kHz. But after noise exposure, the alcohol group showed no significant difference of hearing recovery at all tested times when compared with the control group. HIF1-ɑ expression was decreased in the alcohol group compared with the control group before and after noise exposure. *Conclusion:* Low-dose chronic alcohol provoked elevated thresholds before noise exposure in CBA mice. However chronic alcohol intake didn't influence the recovery from TTS.

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P.2 – Thu 27 Aug, 17:00-19:00

Are temporary threshold shifts reflected in the auditory brainstem response?

Lou-Ann Christensen Andersen**[*,S]**, Ture Andersen - *Institute of Clinical Research, University of Southern Denmark, Odense, Denmark*
Ellen Raben Pedersen - *The Maersk Mc-Kinney Moller Institute, University of Southern Denmark, Odense, Denmark*
Jesper Hvass Schmidt - *Institute of Clinical Research, University of Southern Denmark, Odense, Denmark; Department of Audiology, Odense University Hospital, Odense, Denmark*

Background: Temporary hearing loss in connection with excessive exposure to sound is described as temporary threshold shift (TTS). The auditory cortex has via the corticofugal descending auditory system the position to directly affect the medial olivocochlear system (MOCS) and the excitation level of the cochlear nucleus. One of the functions of MOCS may be to protect the inner ear from noise exposure. *Objective:* The primary purpose was to investigate the influence of auditory attention on TTSs measured with distortion product otoacoustic emissions (DPOAEs) and auditory brainstem responses (ABRs) using noise, familiar, and unfamiliar music as auditory exposure stimulus, respectively. The secondary purpose was to investigate a possible difference in the magnitude of TTS after exposure to the three different sound stimuli. *Method:* Normal-hearing subjects were exposed to the three different sound stimuli in randomized order on separate days. Each stimulus was 10 minutes long and the average sound pressure level was 100 dB linear (96-97 dBA). Pre and post-exposure DPOAEs at 2, 3, and 4 kHz and ABRs at 4 kHz were conducted immediately after the sound exposure. *Results:* Temporary results show a tendency towards an increase in the ABR amplitude for Jewit I, representing action potentials in the spiral ganglion neuron, from the left ear immediately after sound exposure.

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P.3 – Wed 26 Aug, 17:00-19:00

Best application of head-related transfer functions for competing-voices speech recognition in hearing-impaired listeners

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Speech separation algorithms, such as sum/delay beamformers, disturb spatial cues. When presenting separated speech sources over hearing aids, should the spatial cues be restored? The answer was sought by presenting speech sources to a listener via headphones, either directly or after application of head-related-transfer functions (HRTF) to simulate free-field listening. The HRTF application provides both a monaural effect in the form of a substantial high-frequency gain due to the outer ear (pinna and ear canal) and a binaural effect composed of interaural level and time differences. The monaural effect adds audibility, which is crucial for hearing-impaired listeners and the binaural effect adds spatial unmasking cues, which may also be beneficial. For the presentation of two competing voices, we have measured the relative monaural and binaural contributions to speech intelligibility using a previously developed competing voices test. Two consecutive tests, using 13 and 10 hearing-impaired listeners with moderate, sloping hearing losses were conducted, combining different HRTF conditions and horizontal plane angles. Preliminary analysis indicates that hearing-impaired listeners do benefit from HRTF application and that the monaural gain component of the HRTF is the main contributor to improved speech recognition.

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P.4 – Thu 27 Aug, 17:00-19:00

Predicting masking release of lateralized speech

Alexandre Chabot-Leclerc*, Ewen N. MacDonald, Torsten Dau *- Hearing Systems, Department of Electrical Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark*

Locsei et al. [2015, Speech in Noise Workshop, Copenhagen, pp.46] measured speech reception thresholds (SRTs) in anechoic conditions where the target speech and the maskers were lateralized using interaural time delays. The maskers were speech-shaped noise (SSN) and reversed babble (RB) with two, four, or 8 talkers. For a given interferer type, the number of maskers presented on the target's side was varied, such that none, some, or all maskers were presented on the same side as the target. In general, SRTs did not vary significantly when at least one masker was presented on the same side as the target. The largest masking release (MR) was observed when all maskers were on the opposite side of the target. The data could be accounted for using a binaural extension of the sEPSM model [Jørgensen and Dau, J. Acoust. Soc. Am. 130(3), 1475–1487], which uses a short-term equalization–cancellation process to model binaural unmasking. The modeling results suggest that, in these conditions, explicit top-down processing, such as streaming, is not required and that the MR could be fully accounted for by only bottom-up processes. However, independent access to the noisy speech and the noise alone by the model could be considered as implicit streaming and should therefore be taken into account when considering "bottom-up" models.

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P.5 – Wed 26 Aug, 17:00-19:00

Longterm changes of music perception in Korean cochlear-implant listeners

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The purpose of this study was to assess long-term post-implant changes in music perception in cochlear implant (CI) listeners. The music perception ability of 27 participants (5 men 22 women) was evaluated with the Korean version of the Clinical Assessment of Music Perception test which consists of pitch discrimination, melody identification, and timbre identification. Also, a questionnaire was used to quantify listening habits and level of musical experience. Mean postoperative durations of first and second test were 12.8 and 30.9 months. Participants were divided into 2 groups: good or poor performance in the first test with reference to the average of each performance. Pitch discrimination of the second test in the good performance group showed no difference with the first test ($p=0.462$), but in the poor performance group, the pitch discrimination score significantly improved ($p=0.006$). The second test results of the good performance group were still better than the poor performance group ($p=0.002$). In the melody identification test, the two groups showed no change at the second test. The timbre test result was the same feature as the pitch test. The poor performance group in the timbre test had improved in the second test ($p=0.029$). Scores for listening habit and level of musical experience significantly decreased postoperatively ($p=0.06$ and $p<0.001$ respectively) without time-dependent improvement.

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P.6 – Thu 27 Aug, 17:00-19:00

Stimulus ratio dependence of distortion-product otoacoustic emissions below 0.3 kHz in humans

Anders T. Christensen, Rodrigo Ordoñez, Dorte Hammershøi* *- Department of Electronic Systems, Aalborg University, Aalborg, Denmark*

Distinct features in distortion-product otoacoustic emissions (DPOAEs) occur as a result of distinct stimulus conditions or distinct features in the ear. A typical measurement follows “optimal” stimulus parameters to reduce the stimulus dependence and allow for studies of individual ear features. Optimal stimulus parameters are traditionally defined as those giving the maximum DPOAE level at the distortion-product frequency 2f1-f2, where f1 and f2 are the frequencies of two stimulus tones. Dependencies on the stimulus levels L1 and L2 and the stimulus ratio f2/f1 have been determined almost exclusively for f2 frequencies above 1 kHz. To explore the DPOAE below this well-known range of frequencies, we have designed an acoustic probe that works with higher signal-to-noise ratio and less harmonic distortion than commercial alternatives below 1 kHz. While physiological noise tends to be too high below about 0.06 kHz, the microphones have a flat response from 0.03 to 1 kHz. We are currently conducting an experiment to investigate the prevalence of DPOAEs for 2f1-f2 frequencies below 0.3 kHz and get an indication of the optimal stimulus ratio.

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P.7 – Wed 26 Aug, 17:00-19:00

Predicting individual hearing-aid preference in the field using laboratory paired comparisons

Martin Dahlquist, Josefina Larsson, Sofia Hertzman, Florian Wolters, Karolina Smeds* - *Widex A/S ORCA Europe, Stockholm, Sweden*

Two hearing-aid gain settings were compared in two hearing-aid programs. Twenty participants with impaired hearing evaluated the settings during a two-week field trial period using a double-blind design. During the field test, the participants used a diary to report which program they preferred in which scenario. After the field trial, the participants stated their overall preferred setting in an interview and answered questions about their preferred setting in various sound scenarios. In the lab, the participants made paired comparisons of preference, speech clarity, comfort, and loudness. In the analysis we investigated if the laboratory test results could predict the field-trial overall preference. On a group level, it looked as if the results from the diary and questionnaire (field) agreed well with the paired comparisons (lab). However, on an individual level, the paired-comparison test was not effective in predicting real-life overall preference. Potential reasons for this result and the consequences of the result will be discussed.

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P.8 – Thu 27 Aug, 17:00-19:00

Evaluating outcome of auditory training

Carsten Daugaard* - *DELTA, Odense, Denmark*
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Various articles suggest that better speech understanding can be obtained by auditory training. Auditory training typically consists of training speech perception in varying background noise levels or with degraded speech signals. Recently a Danish material for auditory training has been developed. This material consists of music training examples as well as speech training exercises. The rationale behind adding music training is variation in exercises as well as calling attention to details in auditory perception that could be valuable in speech perception as well as in hearing aid fitting. The results presented in this poster originate from examination of the benefits this material can provide on speech perception. Results from the investigation show an average benefit of auditory training, but with a large interpersonal variation, suggesting that a pre-selection of the individuals better suited for auditory training is needed. Suggestions for parameters influencing the success of training are discussed. A battery of cognitive tests has been applied pre- and post-training, results from these tests are presented and discussed, in order to determine if there is correlation between cognition in general, improvement in cognition by auditory training, and obtaining better speech understanding by auditory training.

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P.9 – Wed 26 Aug, 17:00-19:00

Investigating low-frequency compression using the Grid method

Michal Fereczkowski*, Ewen N. MacDonald, Torsten Dau *- Hearing Systems, Department of Electrical Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark*

There is an ongoing discussion whether the amount of cochlear compression in humans at low frequencies (below 1 kHz) is as high as that at higher frequencies. It is controversial whether the compression affects the slope of the off-frequency forward masking curves at those frequencies. Here, the Grid method with a 2-interval 1-up 3-down tracking rule was applied to estimate forward masking curves at two characteristic frequencies – 500 Hz and 4000 Hz. The resulting curves and the corresponding basilar membrane input-output functions were found to be comparable to those found in literature. Moreover, low-level portions of the basilar membrane I/O functions collected for a 500-Hz centre frequency are tested for expansive behaviour, to determine whether the 500-Hz off-frequency forward masking curves were affected by compression. Overall, the collected data showed a trend confirming the expansive behaviour. However, the analysis was complicated by unexpectedly steep portions of the collected on- and off-frequency temporal masking curves.

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P.10 – Thu 27 Aug, 17:00-19:00

How to evaluate binaural hearing with hearing aids in patients with asymmetrical or unilateral hearing loss?

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Gertjan Dingemanse - *Erasmus University Medical Centre, Rotterdam, The Netherlands*

Purpose: Patients with asymmetrical hearing losses or unilateral hearing losses often suffer from bad hearing at the poor side, from localisation problems, and from poor speech understanding in noise. *Method:* In many cases speech audiometry in free field is an effective tool to decide whether speech understanding is equivalent for both aided ears, making binaural interaction possible. However, it is difficult to evaluate the effectiveness of each (aided) ear separately. This is due to the fact that sound generated in free field can reach both ears, i.e., also the non-test ear. The sound can reach the non-test ear in two ways: directly from the loudspeaker, and indirectly by transcranial transmission via the test ear (cross-hearing). In many clinics the non-test ear is "masked" by a foam plug and/or earmuffs. This method helps to minimise the effect of hearing direct sound at the non-test ear. However, cross hearing cannot been ruled out by this method. *Conclusion:* We suggest a new method of contralateral masking, while stimulating in free field. Theoretical considerations are outlined to determine the masking levels necessary to mask sufficiently, and to avoid too much masking (cross-masking). For most asymmetric hearing losses a simple rule can be used.

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P.11 – Wed 26 Aug, 17:00-19:00

Can place-specific cochlear dispersion be represented by auditory steady-state responses?

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The present study investigated to what extent properties of local cochlear dispersion can be objectively assessed through auditory steady-state responses (ASSR). It was hypothesized that stimuli compensating for the phase response at a particular cochlear location and best frequency would generate a maximally modulated basilar membrane (BM) response at that BM position which, in turn, would lead to a larger ASSR amplitude than other stimuli of corresponding bandwidth. Two stimulus types were chosen: 1) harmonic tone complexes with components between 400 Hz and 1600 Hz consisting of equal-amplitude tones with a starting phase following an algorithm developed by Schroeder [1970, IEEE Trans. Inf. Theory 16, 85-89]; and 2) estimated auditory-filter impulse responses (IR) and their temporally reversed versions. The ASSRs obtained with the Schroeder tone complexes were found to be dominated by "across-channel" synchrony and, thus, do not sufficiently reflect place-specific information. In the case of the more frequency-specific stimuli, no significant differences were found between the responses to the IR and its temporally reversed counterpart. Thus, whereas ASSRs to narrowband stimuli have been used as an objective indicator of frequency-specific hearing sensitivity, the method is not sensitive enough to reflect local cochlear dispersion.

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P.12 – Thu 27 Aug, 17:00-19:00

Effects of auditory acclimatisation to bilateral amplification on audio-visual sentence-in-noise processing and speech-evoked potentials

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Recently, Wendt et al. [2014, PLoS ONE 2014] developed an eye-tracking paradigm for estimating how quickly a participant can grasp the meaning of audio-visual sentence-in-noise stimuli (the "processing time"). Using this paradigm, Wendt et al. [2015, Trends Hear.] and Habicht et al. [2015, DGA] found that hearing-impaired listeners with prior hearing aid (HA) experience performed faster on this task than hearing-impaired listeners without any HA experience. To better understand this finding the current study investigated the effects of auditory acclimatisation to bilateral amplification on this task using a longitudinal study design. Groups of novice and experienced HA users (N = ca. 15 each) took part. The novice users were tested before and after 12 weeks of acclimatisation to bilateral HAs. The experienced users were tested with their own devices over the same time period. In addition to the processing time measurements, speech-evoked potentials were also measured. From the results, it is expected that acclimatisation to bilateral amplification will result (1) in shorter processing times and (2) in larger amplitudes and shorter latencies of late auditory potentials, and (3) that for the experienced users no such changes will be apparent.

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P.13 – Wed 26 Aug, 17:00-19:00

Noise reduction in multi-talker babble – Friend or foe?

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Speech comprehension in multi-talker situations is a well-known real-life challenge, particularly for hearing-impaired listeners. Commercially available hearing aids offer various possibilities beyond gain prescription to support those with hearing loss. Here, we investigated whether different strengths of noise reduction algorithms or different strengths of compression would be beneficial for speech comprehension in a realistic multi-talker situation in the lab. In particular we used an auditory number comparison task embedded in cafeteria noise. Sixteen mild to moderate hearing impaired subjects participated in the study. The subjects were fitted with commercially available hearing aids with open domes. The parameters for noise reduction and compression were chosen as available in the fitting software. As dependent measures, perceptual sensitivity (d') and reaction times were analyzed. Overall, the strength of the noise reduction significantly affected perceptual sensitivity of participants performing the task in the experimental set-up, whereas the variation in compression strength did not. Surprisingly, listeners performed significantly better with weaker noise reduction strength. In sum, these results point toward the need for a careful selection of noise reduction parameters in order to ease communication in complex multi-talker situations.

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P.14 – Thu 27 Aug, 17:00-19:00

Modeling the role of spectral details in the binaural room impulse response for sound externalization

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Individual binaural room impulse responses (BRIRs) were recorded at a distance of 1.5 meters for azimuth angles of 0° and 50° in a reverberant room. The spectral details were reduced in either the direct or reverberant part of the BRIRs by averaging the magnitude responses with bandpass filters. For various filter bandwidths, the modified BRIRs were convolved with broadband noise (50-6000 Hz) and listeners judged the perceived position of the noise when virtualized over headphones. Only reductions in spectral details of the direct part obtained with filter bandwidths broader than one equivalent rectangular bandwidth affected externalization. Reductions in spectral details of the reverberant part did not affect externalization to the same degree. In both conditions, a greater sensitivity was observed at 0° than at 50°. To characterise the auditory processes that may be involved in the perception of externalization for reduced spectral details in the BRIR, a quantitative model is proposed. The model includes an echo-suppression mechanism, a filterbank describing the frequency selectivity in the cochlea and a binaural stage that measures the deviations of the interaural level differences between the considered input and the unmodified input. These deviations, integrated across frequency, are then mapped in the model to a value that corresponds to the perceived externalization.

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P.15 – Wed 26 Aug, 17:00-19:00

Subjective listening effort and electrodermal activity in listening situations with reverberation and noise for normal-hearing and hearing-impaired listeners

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Disturbing factors such as reverberation or ambient noise can aggravate speech intelligibility and enhance listening effort, which is needed for communication in daily life. Situations in which listening effort is high are said to imply an increased stress for the listener. The aim of this study was to assess listening effort in situations with background noise and reverberation. For this purpose a subjective scaling of the listening effort together with the electrodermal activity (EDA) as a measure of the autonomic stress reaction were used. Ten young normal-hearing and 17 elderly hearing-impaired participants listened to sentences from the Oldenburg sentence test in stationary background noise and reverberation. In all, four listening situations were generated, an easy and a difficult one for both disturbing factors, which were related to each other by the speech transmission index. The results of the subjective scaling show significant differences between the easy and the difficult listening situations in both subject groups. However, various analyses of the EDA values indicate differences between the results of the groups. For the normal-hearing listeners similar tendencies to the subjective results are visible in the objective values. But for the hearing-impaired listeners these effects in the EDA values are less pronounced.

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P.16 – Thu 27 Aug, 17:00-19:00

Signs of noise-induced neural degeneration in humans

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Animal studies demonstrated that noise exposure causes a primary and selective loss of auditory-nerve fibers with low spontaneous firing rate. This neuronal impairment, if also present in humans, has been assumed to affect the processing of supra-threshold stimuli, especially in the presence of background noise, while leaving the processing of low-level stimuli unaffected. The purpose of this study was to investigate if signs of such primary neural damage from noise-exposure could also be found in noise-exposed human individuals. It was investigated: (1) if noise-exposed listeners with hearing thresholds within the "normal" range perform poorer in terms of their speech recognition threshold in noise (SRTN), and (2) if auditory brainstem responses (ABR) reveal lower amplitude of wave I in the noise-exposed listeners. A test group of noise/music-exposed individuals and a control group were recruited. All subjects were 18-32 years of age and had pure-tone thresholds ≤ 20 dB HL from 125-8000 Hz. Despite normal pure-tone thresholds, the noise-exposed listeners required a significantly better signal-to-noise ratio at the SRTN, compared to the control group ($p < 0.001$). The ABR results showed an amplitude reduction of wave-I; however, the effect was only significant in the left ear. Overall, the results suggest that noise exposure also causes primary neural degeneration in humans.

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P.17 – Wed 26 Aug, 17:00-19:00

Age and objective measures of functional hearing abilities

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The hearing impaired often have difficulties understanding sounds in a noisy background. This ability relies on the capacity of the auditory system to process temporal information. In this study we examined relationships between age and sensitivity to temporal fine-structure, brainstem encoding of harmonic and modulated sounds, and understanding speech in noise. Understanding these links will allow the detection of changes in functional hearing before permanent threshold shifts occur. We measured temporal fine-structure (TFS) sensitivity, brainstem responses and speech in noise performance in 34 adults aged from 18 to 60 years. Cross-correlating the stimulus waveforms and scalp-recorded brainstem responses generated a simple measure of stimulus encoding accuracy. Speech-in-noise performance was negatively correlated with TFS sensitivity and age. TFS sensitivity was also positively correlated with stimulus encoding accuracy for the complex harmonic stimulus, while increasing age was associated with lower stimulus encoding accuracy for the modulated tone stimulus. The results show that even in a group of people with normal hearing, increasing age was associated with reduced speech understanding, reduced TFS sensitivity, and reduced stimulus encoding accuracy (for the modulated stimulus). People with good TFS sensitivity also generally had more faithful brainstem encoding of the harmonic tone.

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P.18 – Thu 27 Aug, 17:00-19:00

Effect of aided hearing in the nonimplanted ear on bimodal hearing

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Bimodal hearing, bilateral auditory input by a unilateral CI and a hearing aid (HA) in the nonimplanted ear, can be applied to take advantage of binaural hearing (head shadow effect, binaural summation, and binaural squelch). Subjects included 17 individuals who continued to use a hearing aid (HA) in the nonimplanted ear for more than 6 months postoperatively. The test material consisted of disyllable words from Korean standard speech perception test material. Speech perception scores (mean ± SD) of unilateral CI and bimodal hearing were 63.3% ± 17.7% and 73.1% ± 18.5% under the quiet condition ($p = 0.029$) and 65.5% ± 21.9% and 70.9% ± 23.6% under the noisy condition ($p = 0.01$), respectively. Angle differences (mean ± SD) of unilateral CI and bimodal hearing were 72.8 ± 27.4 degrees and 84.1 ± 29.9 degrees under the quiet condition ($p = 0.052$) and 79.3 ± 26.9 degrees and 77.3 ± 22.0 degrees under the noisy condition ($p = 0.906$), respectively. Based on the relationship between the aided hearing level and bimodal hearing performance, this current study suggests that bimodal benefits for sound localization and speech perception in noise are significant but only when the aided hearing threshold in the nonimplanted ear is less than 50 dB HL. Therefore, bimodal hearing could be applied to selective patients with favorable aided hearing levels.

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P.19 – Wed 26 Aug, 17:00-19:00

Model of auditory nerve responses to electrical stimulation

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Cochlear implants stimulate the auditory nerve with trains of biphasic pulses. Single-neuron recordings in the cat auditory nerve show, however, that either phase of a biphasic pulses, in isolation can generate an action potential (AP). The site of AP generation differs for both phases, being more central for the anodic phase and more peripheral for the cathodic phase. This results in an average difference of 200 μs in spike latency for AP generated by anodic vs cathodic pulses. Previous models fail to predict the observed latency difference and therefore cannot be used to investigate temporal processing in CI listeners. Based on these premises, a model of the AN responses to electrical stimulation is proposed, consisting of two exponential integrate-and-fire type neurons, representative of the peripheral and central sites of excitation. This model, parameterized with data for monophasic stimulation, is able to correctly predict the responses to a number of pulse shapes. The model is extended for the case of stimulation with pulse trains by include changes in excitability following either subthreshold or suprathreshold stimulation by including a variable representing an adapting threshold. With an adaptive threshold, the model is tested for its ability to predict facilitation (increased excitability following subthreshold prepulse), accommodation (decreased excitability following subthreshold pre-pulse and facilitation), and adaptation (decreased excitability following a spike produced by supra-threshold pre-pulse). The model will be further tested for its ability to predict the observed responses for pulse trains by analyzing effects of stimulation rate and level on the model responses.

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P.20 – Thu 27 Aug, 17:00-19:00

A smartphone-based, privacy-aware recording system for the assessment of everyday listening situations

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When trying to quantify hearing difficulties in every-day listening situations, mostly questionnaires are used to collect and evaluate subjective impressions. Obtaining objective data outside a laboratory is relatively difficult, given the required equipment and its proper handling as well as privacy concerns emerging from long-term audio recordings in a non-regulated and populated environment. Therefore, a smartphone-based system was developed that allows long-term ecological momentary assessment. Microphones are placed close to the ears to obtain signal characteristics, e.g., interaural level differences, similar to those perceived by a listener. Currently, RMS, averaged spectra, and the zero crossing rate are calculated. Additional features can be implemented and the flexibility of the smartphone itself allows for additional functionality, e.g., subjective ratings on predefined scales. A simple user interface ensures that the system can be properly handled by non-tech-savvy users. As only the extracted features but not the audio-data itself are stored, screening and approval of the recorded data by the test subject is not necessary. Furthermore, more standard features, e.g., the spectral centroid, can be computed offline, utilizing the recorded features.

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P.21 – Wed 26 Aug, 17:00-19:00

Auditory-model based assessment of the effects of hearing loss and hearing-aid compression on spectral and temporal resolution

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Most state-of-the-art hearing aids apply multi-channel dynamic-range compression (DRC). Such designs have the potential to emulate, at least to some degree, the processing that takes place in the healthy auditory system. One way to assess hearing-aid performance is to measure speech intelligibility. However, due to the complexity of speech and its robustness to spectral and temporal alterations, the effects of DRC on speech perception have been mixed and controversial [Edwards, 2004]. The goal of the present study was to obtain a clearer understanding of the interplay between hearing loss and DRC by means of auditory modeling. Inspired by the work of Edwards [2002], we studied the effects of DRC on a set of relatively basic outcome measures, such as forward masking functions [Glasberg and Moore, 1987] and spectral masking patterns [Moore et al., 1998], obtained at several masker levels and frequencies. Outcomes were simulated using the auditory processing model of Jepsen et al. [2008] with the front end modified to include effects of hearing impairment and DRC. The results were compared to experimental data from normal-hearing and hearing-impaired listeners.

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P.22 – Thu 27 Aug, 17:00-19:00

Compensating for impaired prosody perception in cochlear implant recipients: A novel approach using speech preprocessing

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Due to inherent device limitations, cochlear implant (CI) recipients are provided with greatly reduced pitch information. However, detecting changes in pitch is necessary to perceive intonation, a main feature of prosody. Therefore, CI recipients' ability to perceive prosody is typically below that of normal-hearing subjects. We propose a novel preprocessing algorithm to enhance intonation perception by broadening the range of pitch changes in speech signals. To proof this concept, we have developed the pitch range extension (PREX) algorithm. PREX is capable of low-delay pitch modifications to speech signals. In addition, it provides automatic and intonation based amplification of pitch movements. In an evaluation with 23 CI recipients, the proposed algorithm significantly improved intonation perception in a question vs. statement experiment. However, the improved performance of CI subjects was still inferior to the performance of normal-hearing subjects. The results support the idea that preprocessing algorithms can improve the perception of prosodic speech features. Furthermore, we suggest utilizing the PREX algorithm for individualized treatment and rehabilitation.

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P.23 – Wed 26 Aug, 17:00-19:00

Frequency selectivity improvements in individual cochlear implant users with a biologically-inspired preprocessing algorithm

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The ability to distinguish between two sounds of different frequency is known as frequency selectivity, which can be quantified using psychoacoustic tuning curves (PTCs). Normal-hearing (NH) listeners show level- and frequency-dependent sharp PTCs, whereas frequency selectivity is strongly reduced in Cochlear Implant (CI) users. This study aims at (i) assessing the individual shapes of PTCs measured psycho-acoustically in CI listeners, (ii) comparing these shapes to those of simulated CI listeners, and (iii) improving the sharpness of PTCs using a biologically-inspired preprocessing algorithm. A 3-alternative-forced-choice forward masking technique was used to assess PTCs in eight CI users (with their own speech processor) and 11 NH listeners (with and without listening to a vocoder to simulate electric hearing). CI users showed large inter-individual variability in sharpness, whereas simulated CI listeners had shallow, but homogeneous PTCs. Furthermore, a biologically-inspired dynamic compression algorithm was used to process the stimuli before entering the speech processor or the vocoder simulation. This algorithm was able to partially restore frequency selectivity in both groups, meaning significantly sharper PTCs than unprocessed. Mechanisms of the algorithm for providing improvement will be discussed. [Supported by DFG cluster of excellence Hearing4all]

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P.24 – Thu 27 Aug, 17:00-19:00

The comparison of efficiency in moderate hearing loss between receiver-in-the-canal (RIC) and completely-in-the-canal (CIC) hearing aids

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Objectives: The purposes of this study were to compare objective and subjective outcomes between RIC and CIC hearing aids (HAs) and to evaluate their efficiency in moderate hearing loss patients. *Methods:* Thirty eight adult patients were included in this study, who had moderate hearing loss (40~70 dB) at 1000Hz with a slope hearing loss. Nineteen patients were fitted with CIC or RIC, respectively. Objective outcomes were evaluated with pure tone audiometry and hearing in noise test (HINT). These tests were performed before the fitting, 2 weeks and 2~3 months after the fitting. Subjective satisfactions were evaluated with attitude toward loss of hearing questionnaire (ALHQ) and Korean version of international outcome inventory-hearing aids (K-IOI-HA). *Results:* There was no significant difference in the functional gain between both groups. But after 2~3 months, there was better functional gain at 500Hz in the CIC group compared to the RIC group. There was no significant difference in the degree of improvement in HINT between both groups. In ALHQ, RIC group showed significantly better SEI subscale score than CIC group. But there was no significant difference in the result of K-IOI-HA. *Conclusion:* Comparing the outcomes of CIC and RIC in the moderate hearing loss, there was no large difference in the objective benefits. However, RIC users showed a better social and emotional impact.

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P.25 – Wed 26 Aug, 17:00-19:00

Simple spectral subtraction method enhances speech intelligibility in noise for cochlear implant listeners

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It is demonstrated that while clean speech is well intelligible by most cochlear implant (CI) listeners, noise quickly degrades speech intelligibility. To remedy the situation, CI manufacturers integrate noise reduction (NR) algorithms (often using multiple microphones) in their CI processors, and they report CI users to benefit from this measure. We have implemented a single-microphone NR scheme based on spectral subtraction with minimum statistics to see if such a simple algorithm can also effectively increase speech intelligibility in noise. We measured speech reception thresholds using both speech-shaped and car noise in 5 CI users and 23 normal-hearing listeners. For the latter group, CI hearing was acoustically simulated. In case of the CI users, the performance of the proposed NR algorithm was also compared to that of the CI processor's built-in one. Our NR algorithm enhances intelligibility greatly in combination with the acoustic simulation regardless of the noise type; these effects are highly significant. For the CI users, trends agree with the above finding (for both the proposed and the built-in NR algorithms). However, due to low sample number, these differences did not reach statistical significance. We conclude that simple spectral subtraction can enhance speech intelligibility in noise for CI listeners and may even keep up with proprietary NR algorithms.

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P.26 – Thu 27 Aug, 17:00-19:00

Lateralized speech perception in normal-hearing and hearing-impaired listeners and its relationship to temporal processing

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This study aimed to investigate the role of temporal fine structure (TFS) coding in spatially complex, lateralized listening tasks. Speech reception thresholds (SRTs) were measured in young normal-hearing (NH) and two groups of elderly hearing-impaired (HI) listeners in the presence of speech-shaped noise and different interfering talker conditions. The HI subjects had either a mild or moderate hearing loss above 1.5 kHz and reduced audibility was compensated for individually in the speech tests. The target and masker streams were presented as coming from the same or from the opposite side of the head by introducing 0.7-ms ITDs between the ears. To assess the robustness of TFS coding, frequency discrimination thresholds (FDTs) and interaural phase difference thresholds (IPDTs) were measured at 250 Hz. While SRTs of the NH subjects were clearly better than those of the HI listeners, group differences in binaural benefit due to spatial separation of the maskers from the target remained small. Neither the FDT nor the IPDT tasks showed a clear correlation pattern with the SRTs or with the amount of binaural benefit, respectively. The results suggest that, although HI listeners with normal hearing in the low-frequency range might have elevated SRTs, the binaural benefit they experience due to spatial separation of competing sources can remain similar to that of NH listeners.

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P.27 – Wed 26 Aug, 17:00-19:00

Sensitivity to angular and radial source movements in anechoic and echoic single- and multi-source scenarios for listeners with normal and impaired hearing

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So far, very little is known about the perception of spatially dynamic sounds, especially under more complex acoustic conditions. Therefore this study investigated the influence of reverberation and the number of concurrent sources on movement perception with both normal-hearing and hearing-impaired listeners. Virtual environments were simulated with the help of the “Toolbox for Acoustic Scene Creation and Rendering” (TASCAR) [Grimm and Hohmann, 2014, Proc. Ger. Audiol. Soc.], which is a higher-order Ambisonics-based system that allows rendering complex scenarios with high physical accuracy. Natural environmental sounds were used as the stimuli. Both radial (front-back) and angular (left-right) movement perception was considered. The complexity of the scenarios was changed by adding stationary sound sources as well as reverberation. From the results, it is expected that an increase in complexity will generally result in reduced sensitivity to both angular and radial movement perception, and that the normal-hearing listeners will generally outperform the hearing-impaired listeners, in particular under more complex acoustic conditions.

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P.28 – Thu 27 Aug, 17:00-19:00

Effect of harmonic rank on streaming of complex tones

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The effect of the rank of harmonics on sequential stream segregation of complex tones was investigated for normal-hearing (NH) and hearing-impaired (HI) listeners. It was hypothesized that stream segregation would be greater for tones with high pitch salience. For NH listeners, pitch salience is highest for tones containing some low (resolved) harmonics, but is also fairly high for tones containing harmonics of intermediate rank. HI listeners have wider auditory filters than NH listeners, and this leads to poorer resolution of harmonics and lower pitch salience for the former [Moore and Glasberg, 2011, J. Acoust. Soc. Am. 130, 2891-2901]. This might lead to reduced stream segregation for tones with low and intermediate harmonics. Stream segregation was assessed for tones that were bandpass filtered between 2 and 4 kHz. Harmonic rank was varied by changing the fundamental frequency. In contrast to an earlier study [Vliegen and Oxenham, 1999, J. Acoust. Soc. Am. 105, 339-346], NH listeners showed decreasing stream segregation with increasing harmonic rank.

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P.29 – Wed 26 Aug, 17:00-19:00

Perceptual space induced by cochlear implant all-polar stimulation mode

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It has often been argued that a main limitation of the cochlear implant is the spread of current induced by each electrode that activates large range of sensory neurons. In order to reduce this spread, a new strategy, the all-polar mode, was tested with 5 patients. It was designed to activate all the electrodes simultaneously with appropriate current levels to minimise unwanted interaction and to recruit narrower regions of auditory nerves. In this study, the sound quality of the all-polar mode was compared to the current commercial stimulation mode: the monopolar mode. The patients were asked to judge the sound dissimilarity between pairs of dual-channel stimuli presented in both modes. The dissimilarity ratings were analysed with a multidimensional scaling technic and a two-dimensional space was produced. For both modes, the first dimension was highly correlated with the average position of the electrical stimulation and the second dimension moderately with its width. Although the all-polar and monopolar perceptual spaces largely overlap, a shift upward along the first dimension can be observed for the all-polar stimuli. This suggested that the all-polar stimuli are perceived with a higher pitch than the monopolar stimuli. [The Bionics Institute acknowledges the support it receives from the Victorian Government through its Operational Infrastructure Support Program.]

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P.30 – Thu 27 Aug, 17:00-19:00

Statistical representation of sound textures in the impaired auditory system

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Many challenges exist when it comes to understanding and compensating for hearing impairment. Traditional methods such as pure tone audiometry and speech intelligibility tests offer insight into the deficiencies of a hearing impaired listener, but can only partially reveal the mechanism that underlie the hearing loss. An alternate approach is to investigate the statistical representation of sounds for hearing-impaired listeners along the auditory pathway. Using models of the auditory periphery and sound synthesis, we aim to probe hearing impaired perception for sound textures – temporally homogenous sounds such as rain, birds, and fire. It has been suggested that sound texture perception is mediated by time-averaged statistics measured from representations of the early auditory system. Changes to early auditory processing, such as broader “peripheral” filters or reduced compression, alter the statistical representation of sound textures. For normal hearing listeners, these modifications yield poorer synthesis performance. However, it is not yet known how these changes will affect sound texture perception for hearing impaired listeners. Future work will focus on texture statistics based compensation strategies applied to an impaired model of the auditory periphery, focusing on the loss of frequency selectivity and reduction in compression.

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Revealing auditory nerve fiber loss in humans using auditory brainstem response wave-V latency

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Recent animal studies show that noise-induced loss of auditory nerve fibers (ANFs) reduces auditory brainstem response wave-I amplitudes (ABRs) without affecting hearing thresholds. Although noise-induced neuropathy affects how ABR wave-I amplitude grows with level, ABR latencies have not been thoroughly investigated. Models suggest that how ABR wave-V latency changes with increasing background noise or due to a preceding masker should be a sensitive measure of ANF survival. We tested these predictions in a series of experiments and found evidence that individual differences in ABR wave-V latency in listeners with normal hearing threshold reflect differences in ANFs. Specifically, we find that wave-V latency rate of change with noise level correlates with the ability to use fine temporal cues: listeners with poor sensitivity to envelope interaural time differences showed smaller changes in wave-V latency with increasing noise. In addition, ABR wave-I amplitude growth with stimulus level was a significant predictor of wave-V latency rate of change with noise level. We also analyzed results from noise-exposed mice and found analogous patterns. In forward masking, listeners with a delayed wave-V latency exhibited higher forward masking behavioral thresholds. Furthermore, listeners with the poorest behavioral thresholds showed evidence of faster recovery from forward masking.

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A new tool for subjective assessment of hearing aid performance: Analyses of interpersonal communication

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The grounded theory is a multifaceted method for systematic qualitative research. The researcher achieves steady assumptions from data in an iterative analytical process. In this study, the approach focuses on insights about human-machine interaction and on the influences different hearing aids algorithms have on communication. We tested a binaural and a monaural beamformer (BF) system in two different acoustical conditions: a soft and a loud group situation. We developed an intermediate procedure between strict laboratory research and a field test in everyday life using two different tools: (1) questionnaires and focus group discussion with a subjective evaluation of the algorithms, individually and in groups; (2) video analyses with external rating of subject‘s communication behavior which is related strongly to the ground theory approach. The questionnaires showed correlations with results from an earlier assessment in real life. The video analysis revealed a higher percentage of face-to-face interactions in the loud situation especially for the binaural BF approach when also verbal communication (ratio symbolic gestures vers. spoken words) was used more for the binaural than for the monaural BF system.

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Model-based analysis of interaural time differences in auditory nerve responses

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Interaural time differences (ITDs) are an important cue for sound localization. It is generally agreed that ITDs are processed by “co-incidence detectors” specialized cells which receive input from the auditory nerve (AN) from both ears. Access to ITDs is often reduced for users of hearing aids (HAs) or cochlear implants (CIs), leading to poor localization performance. This suggests that temporal information is distorted by the introduction of HA or CI processing. In this work, we developed a model-based framework to evaluate temporal coding of ITDs at the AN level. The phenomenological model proposed by Zilany et al. [2009] was used to obtain AN responses to acoustic stimuli with varying ITDs from both ears. Afterwards, shuffled cross-correlograms (SCCs) [Joris et al., 2006] were used to quantify the ITD coding. This framework successfully predicted different ITDs imposed on various stimuli (pure tones, band-pass noise, amplitude modulated tones). Analysis showed that the predicted ITD resolution depended on the size of the SCC coincidence window. These results provide the basis for a quantification of ITD coding in normal-hearing listeners. Future work will be focused in using the current approach to predict ITD discrimination performance in listeners with acoustic and electric hearing and to optimize HA/CI signal processing.

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An objective measurement of TMTF by using envelope of cABR

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It is well known that a temporal resolution of the hearing system is reduced for hearing-impaired listeners. The temporal modulation transfer function (TMTF) was proposed as a one of the measurement methods for temporal resolution. A sinusoidal amplitude-modulated broadband noise (SAM noise) is used in the measurement of TMTF. However, it is much time-consuming. In addition, it is hard for children and foreigners, with limited language ability, to be measured for TMTF which requires subjective response. Therefore, we think that an appropriate objective measurement is necessary in order to avoid any interference on the measurement process. For objective measurement of TMTF, we focused on cABR (auditory brainstem response to complex sounds) which faithfully represents some key acoustical features, e.g., the envelope of complex sound stimuli. It seems that the envelope characteristics of cABR using SAM noise, as complex sound stimuli, can be applied to the objective measurement of TMTF. We found that the envelope of cABR was related to the modulation index of the stimuli. This knowledge suggests that the threshold of modulation index can be estimated from the cABR measurement.

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Individual differences on audiovisual speech perception in people with hearing loss

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Individual differences in audiovisual speech perception in people with hearing loss were investigated using syllables, words, and sentences. The stimuli were presented in auditory-only, visual-only, and auditory-visual conditions for both congruent and incongruent conditions. In the congruent condition auditory speech stimuli were presented with their identical visual cues, and in the incongruent condition auditory stimuli were presented with conflicting visual cues. Nine young adults with varying degrees of hearing loss, that were fit with hearing aids or cochlear implants, participated in the study. The relative increase in performance of audiovisual speech perception tests due to the addition of visual cues to the auditory signal was calculated for each condition. Results showed that the subjects were able to integrate both auditory and visual cues in the auditory-visual congruent condition. The auditory-visual gain in speech perception was reduced in the incongruent condition. The subjects showed significant individual differences in the amount of gain for different experimental conditions. These results suggest that auditory and visual integration of speech information does occur but the degree was different between subjects.

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Relating hearing aid users' preferred noise reduction setting to different measures of noise tolerance and distortion sensitivity

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Recently, there has been growing interest in the personalisation of hearing aid (HA) signal processing. In two previous studies [Neher, 2014, Front. Neurosci. 8:391; Neher et al., 2015, under review], we found that audiometric and cognitive factors could explain some of the inter-individual variability in preferred noise reduction (NR) setting. In the current study, we explored a number of alternative measures in terms of their ability to predict NR preference. Based on data from our previous studies, we recruited groups of HA users with clear preferences for either weak (N = 13) or strong (N = 14) NR processing. We then administered a combination of established and novel psychoacoustic, audiological, and self-report measures of noise tolerance and distortion sensitivity to them. Our ongoing analyses suggest that some (but not all) of the chosen measures allow discriminating between the two groups, and that these measures therefore may yield additional leverage with respect to choosing more individualised NR settings.

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Characterizing individual hearing loss using narrow-band loudness compensation

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Loudness is one of the key factors related to overall satisfaction with hearing aids. Individual loudness functions can reliably be measured using categorical loudness scaling (CLS) without any training. Nevertheless, the use of loudness measurement like CLS is by far less common than use of audiometric thresholds to fit hearing aids, although loudness complaints are one of the most mentioned reasons for revisiting the hearing aid dispenser. A possible reason is that loudness measurements are typically conducted with monaural narrow-band signals while binaural broad-band signals as speech or environmental sounds are typical in daily life. This study investigated individual uncomfortable loudness levels (UCL) with a focus on monaural and binaural broad-band signals, as being more realistic compared to monaural narrow-band signals. A group of normal-hearing listeners served as a reference in this experiment. Hearing-impaired listeners with similar audiograms were aided with a simulated hearing aid, adjusted to compensate the narrow-band loudness perception back to normal. As desired, monaural narrow-band UCLs were restored to normal, however large individual deviations of more than 30 dB were found for the binaural broad-band signal. Results suggest that broadband and binaural loudness measurements add key information about the individual hearing loss beyond the audiogram.

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Comparison of amplification using test-bands with implantable hearing devices in a model of induced unilateral conductive hearing loss

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Objectives: The BAHA system™ (BAHA) and Sophono system™ (Sophono) are bone conduction devices which aid hearing for patients with mixed or conductive hearing loss or single-sided deafness. We wanted to investigate the difference between hearing outcomes of BAHA and Sophono in a model of induced unilateral conductive hearing loss. Methods: A model of unilateral conductive hearing loss was induced by plugging the right ear canal in 30 subjects with no previous hearing loss. A test-band was applied with a recent model of each device (BP 110 POWER® and Sophono a-2 MPO®) applied on the right mastoid tip with the left ear masked. Pure-tone thresholds at six frequencies and word discrimination scores at 40 and 60 dB HL were evaluated. Results: Sophono showed lower aided thresholds compared to BAHA at all frequencies except 500Hz ($p<0.01$). Aided 4-frequency average thresholds (mean 23, ranging 13-31) of Sophono were lower than those of BAHA (mean 29, ranging 19-41), with statistical significance ($p<0.001$). In word recognition scores (WDS), WDS of Sophono (85%) was higher than that of BAHA (73%) at 40 dB HL ($p<0.01$), however WDS of Sophono (98%) was not different from that of BAHA (95%) at 60 dB HL. Conclusions: Our findings showed that both bone conduction devices could provide excellent hearing amplification with better amplification in Sophono by 6-dB difference of aided thresholds.

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Discrimination scores used in medico-legal assessment of hearing disabilities

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Objective: Examination of Danish data for medico-legal compensations regarding hearing disabilities. The purposes are: 1) to investigate whether discrimination scores (DSs) relate to patients' subjective experience of their hearing and communication ability, 2) to compare DSs from different discrimination tests (auditory/audio-visual perception and without/with noise), and 3) to evaluate the handicap scaling used for compensation purposes in Denmark. *Design:* Data for 466 patients from a 15-year period (1999-2014) were analysed. From the data set 50 patients were omitted due to suspicion of exaggerated hearing disabilities. *Results:* The DSs were found to relate well to the patients' subjective experience of their speech perception ability. As expected the least challenging test condition (highest DSs) was the audio-visual test without an interfering noise signal, whereas the most challenging condition (lowest DSs) was the auditory test with noise. The hearing and communication handicap degrees were found to agree, whereas the measured handicap degree tended to be higher than the self-assessed handicap degree. *Conclusions:* The DSs can be used to assess a patient's hearing and communication abilities. In order to get better agreements between the measured and self-assessed handicap degrees it may be considered to revise the handicap scaling.

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Binaural auditory steering strategy promoting off-axis listening and preserving spatial cues

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Hearing in complex acoustic scenes is a challenge for hearing-impaired persons that often persists after amplification is applied even when fitted bilaterally. From a hearing aid (HA) processing point of view there can be several reasons for this. First, directional filters in a symmetric fitting can help increase SNR for on-axis signals of interest. However, they also can render off-axis signals inaudible. Second, HA microphone location can degrade spatial cues that are important for localization and thus listening in complex acoustic scenes. Third, amplification itself, when applied independently at both ears, can affect spatial cues, mainly interaural level differences. Finally, changing acoustic scenes might require changing processing. In order to overcome some of these challenges we propose a bilateral fitting scheme that can be symmetric or asymmetric depending on the acoustic scene. The respective HA processing modes can be (a) omnidirectional, (b) directional, or (c) directional with preservation of spatial cues. In this study it was shown that asymmetric fitting helps improve off-axis audibility when prioritized while it provides natural sound and decreases listening effort for symmetric fitting in situations when audibility is not the main focus.

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Simultaneous measurement of auditory-steady-state responses and otoacoustic emissions to estimate peripheral compression

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Assessment of the compressive nonlinearity in the hearing system provides useful information about the inner ear. Auditory-steady state responses (ASSR) have recently been used to estimate the state of the compressive nonlinearity in the peripheral auditory system. Since it is commonly assumed that outer hair cells play an important role in the compressive nonlinearity, it is desirable to selectively obtain information about the inner ear. The common method to objectively measure inner ear activity is the measurement of distortion-product otoacoustic emissions (DPOAEs) via acoustical signals in the ear canal. The nonlinear nature of generation of the DPOAE complicates the interpretation of the results, especially on an individual basis. In the current study, the signal in the ear canal present during ASSR measurements is utilized to extract sinusoidally-amplitude modulated OAEs (SAMOAEs). The hypothesis is that the stimulus used to evoke ASSRs will cause acoustic energy to be reflected back from the inner ear into the ear canal, where it can be picked up as an OAE. Results indicate that SAMOAEs can be extracted while measuring ASSRs using sinusoidally-amplitude modulated tones. A robust extraction and evaluation of SAMOAE in connection with ASSR provides additional information about the state of the peripheral auditory system without the need of additional measurement time.

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Effects of time of day and cognitive load on aided performance

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A link among hearing loss, fatigue, listening effort, and cognitive drain has been suggested to impact benefit from amplification. Hornsby [2013] investigated the effects of hearing aid (HA) use on effort and fatigue for complex listening, suggesting that these negative consequences can be reduced by using well-fit HAs. To probe into this, an experiment was designed where 14 HA users were tested aided in complex listening tasks on Friday evening, Saturday morning, and late Saturday afternoon. In between the two Saturday tests participants were taken on a tour designed to span a range of challenging listening tasks. This was done twice, using two different levels of hearing technology. Single and dual task versions of the Hearing-in-Noise Test (HINT) were used to test listening abilities. Self-report probed into fatigue and vigor, different aspects of perceived listening and characterized participants as morning, intermediate or evening types. In addition to audiometric measures, the reading span was used to assess cognitive status. Results show that aided listening changed over the course of a day, performance in the morning was not the best despite most participants being morning types and well-rested, and speech understanding was better in the evening despite self-perceived fatigue being increased. Higher technology level did positively affect some objective and subjective listening abilities.

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Towards modelling hearing-impaired speech intelligibility

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The work on speech intelligibility (SI) models started with the articulation index (AI). Models following the AI were extended to consider a larger variety of conditions. Some recent studies predicted SI in normal-hearing (NH) listeners based on a signal-to-noise ratio measure in the envelope domain (SNRenv) [Jørgensen and Dau, 2011; Jørgensen et al., 2013]. This framework showed good agreement with measured data in a broad range of conditions, including stationary and modulated interferers, reverberation, and spectral subtraction. This study investigates to what extent effects of hearing impairment on SI can be modeled in this framework. A first fundamental step towards that goal is to modify the model to account for SI in NH listeners with band-limited stimuli, which resembles SI in HI listeners. This work proposes a signal-based band weighting inspired by the phase opponency model [Carney et al., 2002]. The model looks at the time synchrony of the frequency bands and assigns higher weights to channels that are temporally synchronous. Furthermore, the loss of sensitivity of HI listeners is incorporated into the model. Simulations show that, by only accounting for the sensitivity loss, the model predictions agree with the masking release (MR) data measured in thirteen HI listeners. Further steps for modeling decreased spectral and temporal resolution are briefly outlined.

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Fricative loss and hearing impairment: What doesn't help?

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Speech recognition decreases in noise for normal-hearing and in particular hearing-impaired listeners. The parts of speech that are most likely to be drowned in noise are those that are a type of noise themselves – consonants produced by friction of air between two narrowly placed articulators. To add insult to injury, such fricative consonants are situated predominantly in the high-frequency range where the typical sensorineural hearing loss starts and worsens with age. The aim of this study was to compare different signal processing strategies with the potential to alleviate the above problems: adaptive compression, high-frequency broadband gain, and fricative enhancement. Nine subjects with moderate hearing loss were tested in the lab with all three strategies and at home with the fricative enhancement algorithm and adaptive compression. Both objective and subjective outcome measures were obtained. Whereas lab measures did not reveal significant differences between the algorithms, subjective preferences at home trials were significantly on the side of the adaptive compression. Presumably, the cause for this lies in the difficulty of algorithmic fricative recognition in real life situations. The clearer the speaker and the more steady the environment, the better the recognition but also the lesser the need for fricative enhancement.

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Validating audio-visual speech stimuli for lip-reading and multi-sensory integration in hearing-impaired listeners

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There is converging evidence that the auditory cortex takes over visual functions during a period of auditory deprivation. After implantation of a cochlear implant (CI), the visual take-over seems to limit speech performance on one hand whereas it might be functionally specialized for highly important and ecologically valid face stimuli. This functional specialization in CI users is reflected in stronger lip-reading abilities and in better face recognition. Until now it is unclear when the reorganization process begins. First evidence of an early reorganization was recently found in individuals with a slightly lowered hearing threshold. To better understand the process and the development of cortical cross-modal reorganization, further investigations with normal-hearing, moderately and severely hearing-impaired CI users are needed. For this purpose we developed audio-visual speech material, consisting of eight different speakers (4 females and 4 males). Monosyllabic words allow us to quantify lip reading skills. Audio-visual integration can be investigated with syllables evoking the audio-visual McGurk illusion, which we provide as well. The quality of the material was evaluated with 24 young and normal-hearing subjects and shall be freely available for the research community in the near future.

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For hearing aid noise reduction, babble is not just babble

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Many government and third-party hearing aid funders require that hearing aids provide single-microphone noise reduction algorithms, without specifying how they should work. The current study investigates how the noise reduction is applied to babble noise in current top-level hearing aids. Coupler gain measurements were performed in an acoustic test chamber. The signals used were standardized test signals, as well as babble noises compiled with different number of speakers (2, 4, 6, 8, and 10 speakers). The long-term average gain reduction was calculated by comparing the output of the hearing aids with the noise reduction off versus the strongest setting available. The results showed that, for unmodulated test signals (e.g., ICRA1), the noise reduction algorithms applied quite different amounts of noise reduction (varying from 3 to 12 dB) concentrated in very different frequency regions. None of the algorithms tried to reduce the standardized modulated signals, such as ICRA5. For the babble noise, some of the algorithms did not reduce gain, even for 10-person babble. Other algorithms applied a graduated response, i.e., most gain reduction for 10-person babble, and the least amount of noise reduction for 2-person babble. Along with previous studies, this study highlights the need to have a standardized benchmarking procedure to define how noise reduction works in hearing aids.

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Evaluation of a clinical auditory profile in hearing-aid candidates

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Hearing-impaired (HI) listeners often complain about communicating in the presence of background noise, although audibility may be restored by a hearing aid. The audiogram typically forms the basis for hearing-aid fitting, such that people with similar audiograms are given the same prescription by default. This does not necessary lead to the same hearing-aid benefit. This study aimed at identifying clinically relevant tests that may be informative in addition to the audiogram and relate more directly to hearing-aid benefit. Twenty-nine HI and 26 normal-hearing listeners performed quick tests of loudness perception, spectral and temporal resolution, binaural hearing, speech intelligibility in stationary and fluctuating noise, and a working-memory test. They answered a hearing disability and handicap questionnaire and, six weeks after hearing-aid fitting, the International Outcome Inventory – Hearing Aid questionnaire. While the HI group was homogeneous based on the audiogram, large individual differences were observed in all other tests. Moreover, HI listeners who took the least advantage from fluctuations in background noise in terms of speech intelligibility experienced greater hearing-aid benefit. Further analysis of whether specific outcomes are directly related to speech intelligibility in fluctuating noise could be relevant for concrete hearing-aid fitting applications.

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Simulating hearing loss with a transmission-line model for the optimization of hearing aids

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Modern hearing aids provide many parameters that can be adjusted to optimize the hearing experience of the individual user. Optimization of these parameters can be based on a comparison of an internal representation of sound processed by the hearing aid and the impaired hearing system with the representation in a non-impaired ear. Models that can represent the most common types of hearing loss and can be adjusted to fit individual hearing loss can play a crucial role in such optimization procedures. Simulations will be presented that show the potential of a transmission-line model in such a procedure. The model was extended with a frequency remapping method that may simulate neural deafferentation.

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Auditory model responses to harmonic and inharmonic complex tones: Effects of the cochlear amplifier

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Hopkins and Moore [2007, J. Acoust. Soc. Am. 122, 1055-1068] measured the ability of hearing-impaired (HI) listeners to discriminate harmonic (H) and inharmonic (I) – all harmonics shifted upwards by the same amount in Hz – complexes. The complexes were composed of many bandpass filtered harmonics (shaped stimuli) or five equal-amplitude harmonics (non-shaped stimuli). HI listeners performed more poorly for the shaped than for the non-shaped stimuli. Since shaping of the complexes should minimize envelope and spectral cues, listeners should discriminate H and I stimuli mainly using temporal fine structure (TFS) cues even when the harmonics are not resolved. This ability seems to be worsened in HI listeners. This study employed an auditory model with a physical cochlear model to show how the cochlear amplifier affects responses to H and I stimuli. For the shaped stimuli, TFS of the simulated neural signals for H and I stimuli differed – low cross-correlation coefficients computed from the shuffled cross-correlograms. However, for the passive auditory model (simulating HI), the inter-spike intervals smaller than half of the stimulus period were similar. This could explain the poor performance for HI listeners. For the non-shaped stimuli, differences in the inter-spike intervals were observed even for the passive model which could contribute to the improved performance.

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Impact of background noise and sentence complexity on cognitive processing effort

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Pupil response was recorded (as indicator of cognitive demands) while processing Danish sentences for 20 normal-hearing participants. Sentences were either syntactically simple or complex and presented in either high or low-level background noise. An audio-visual picture-matching task was used to assess speech comprehension performance. Furthermore, participants were asked to rate the effort required for sentence comprehension. The results indicated that the rated effort was affected by the noise level, whereas the effect of the sentence complexity on rated effort was rather small. Conversely, pupil dilation increased with sentence complexity whereas only a minor effect of the noise level on pupil dilation was observed. The results indicated that acoustic noise and linguistic complexity have distinctly different impact on pupil responses and rated effort. Finally, the results suggest that perceived effort appears to be strongly dependent on noise level, and less on sentence complexity. Pupil dilations, in contrast, may reflect working memory processing that is required for speech comprehension but may not necessarily be perceived as effortful. In order to examine whether and to what extent processing effort is linked to working memory, both pupil dilation and perceived effort will in a next step be correlated with working memory capacity in the individual participants.

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Effects of dynamic-range compression on temporal modulation transfer functions and modulation depth discrimination

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Some of the challenges that hearing-aid listeners experience with speech perception in complex acoustic environments may originate from limitations in the temporal processing of sounds. To systematically investigate the influence of hearing impairment and hearing-aid signal processing on temporal processing, temporal modulation transfer functions (TMTFs) and "supra-threshold" modulation-depth discrimination (MDD) thresholds were obtained in normal-hearing (NH) and hearing-impaired (HI) listeners with and without wide-dynamic range compression (WDRC). The TMTFs were obtained using tonal carriers of 1 and 5 kHz and modulation frequencies from 8 to 256 Hz. MDD thresholds were obtained using a reference modulation depth of -15 dB. A compression ratio of 2:1 was chosen. The attack and release time constants were 10 and 60 ms, respectively. The results obtained in the HI group revealed relatively large differences across listeners despite very similar pure-tone sensitivity in terms of their audiograms. The MDD thresholds were in most cases considerably higher than those obtained in the NH group whereas the TMTF patterns were more similar to those of the NH listeners. This indicates that the two measures may represent different aspects of temporal processing. The TMTF and MDD thresholds declined for the WDRC condition similar to the physical compression of the modulation depth.

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P.52 – Thu 27 Aug, 17:00-19:00

Perceptual equivalence of test lists in a monosyllabic speech test with different hearing thresholds

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EN ISO 8253-3 describes the requirements and validation of speech material for speech audiometry. Although speech tests are typically applied to hearing-impaired listeners, the validation is to be conducted with normal-hearing listeners. The aim of the study was to determine the effect of hearing thresholds on the validation results. Since hearing losses of hearing-impaired listeners show a large variability, groups of normal-hearing participants listened to the speech material preprocessed with a simulated homogenous hearing loss as well as to the original speech material. Discrimination functions were fitted to the results and speech level for speech recognition scores of 50%, 60%, 70%, 80%, and 90% were determined. According to EN ISO 8253-3 the perceptual equivalence of the test lists is given when the speech level is within 1 dB from the median across all lists. For the validated German monosyllabic speech test the range of levels between the easiest and the most difficult list was 4.3 dB without hearing loss and 7.5 dB for a simulated hearing loss. Comparisons of easy and difficult lists in both groups indicated similarities as well as differences. The results suggest that if perceptual equivalence is fulfilled for normal-hearing listeners this might not be valid for hearing-impaired listeners.

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Evaluation of speech audiometry in sound-field and real-ear measurements as tools for verification of improvement in hearing ability

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The European standard EN 15927, "Services offered by hearing aid professionals", clause 5.5.4, proposes three main methods for verification of improvement in hearing ability (A. speech audiometry in sound field, B. surveys with real-ear measurements and C. questionnaire concerning the perceived benefit from the hearing aid system). The standard states that at least one of these shall be used and the results reviewed with the client. In this study we have evaluated verification by method A and B for a group of 18 hearing aid users. The hearing aid users were volunteers from our group of "professional patients" and had received hearing instruments prior to this study. For each user the measures of target gain, insertion gain, speech recognition thresholds in silence and noise with or without hearing instruments, and spatial release of masking were obtained. The best binaural pure-tone average (BBPTA) was calculated for each client by selecting the best ear threshold for each of the frequencies at 500, 1000, 2000, and 4000 Hz and averaging. Binaural hearing aid gain was determined by a corresponding procedure. Results from both method A and B will be presented and discussed. For the speech tests, comparisons with normal-hearing results will be presented.

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N.B. In the above programme, * denotes a presenting author and ^{s} a scholarship recipient.

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