2014
Annual Report

ErikshholmResearchCentre
PART OF OTICON

Foreword

Dear reader,

Welcome to this first online version of Eriksholm Research Centre's Annual Report, covering our activities during 2014.

The Annual Report provides an overview of the research work and the dissemination activities which we have been doing over the past year. If you wish to know more about one or more specific projects, please contact the person mentioned in connection with the summary.

If you wish to obtain more general information about Eriksholm Research Centre and a broader overview of finalized research projects, please visit our website at www.eriksholm.com.

Uwe Hermann
Senior Director

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Director's report

During 2014 we have been working intensively with leading universities around the world to explore the four audiological trends mentioned in last year's Annual Report: Brain Computer Interface, e-Audiology and e-Health Care, Behavioural Research and Almost Unlimited Processing Power.

We have merged Behavioural Research and eHealth and continue working within the following three research areas which we see as the three megatrends in audiology:

- **Brain Computer Interface**
- **eHealth**
- **Advanced Algorithms**

Brain Computer Interface
The megatrend Brain Computer Interface has inspired us to go forward with the concept of Ear-EEG. Putting advanced EEG functionality into a hearing instrument sounds challenging, and indeed it is. But the rewards of this new technology will be worth all the efforts which lie in front of us. We will not only be able to develop hearing instruments which will be controlled by the mind of their users. We also get inspiring and encouraging input from researchers in various medical fields who see exciting applications in health care monitoring. Today EEG medical measurements can only be done for short periods and with rather expensive and complicated medical equipment. Ear-EEG will enable us to do long term monitoring - in principle even 24 hours a day and 365 days a year – in a rather simple and user friendly way. Just imagine if it would be possible through such a permanent EEG monitoring to avoid just 1% of stroke incidents! Early intervention triggered by the alarm of an in ear EEG device would become medical routine.

These visions have also convinced the reviewers of our Horizon2020 project application in this field, which was approved with top ranking.

This and further research grants we won in 2014 were not only financial enablers, but also encouragements to further progress within this field of research.

eHealth
We have merged e-Audiology and e-Health Care with Behavior Science under the headline eHealth in order to sharpen our focus in line with our Applied Science Strategy at Eriksholm. We are continuing our ambitious research in behavior science in order to establish clinical evidence and improved user benefits in future eHealth services in audiology.

On a global basis we follow the current revolution in wearable electronics, which was the star of the Consumer Electronics Show in Las Vegas in January 2015. These new technologies and devices are now so mature that one can almost see around the corner which big disruptions they will create in health care within the next years.

At Eriksholm we do not intend just to surf on an eHealth hype, as one could see with many promising pilot projects in eHealth which disappeared after short term again. Our conclusion from analyzing this on a broad scale with peer researchers is that often vital elements for success are missing in this domain:

Internally, companies need to be ready to encounter the disruptive changes these new eHealth technologies create. Disruptions will not only be seen in the tools, technologies and services which are provided, but also in business models and review streams.

Externally, towards the customers, it is rather the opposite. We have to ensure acceptance and a smooth transition by creating eHealth services with significant and clinically proven benefits. As disruptive as these new eHealth services might be for the involved companies, for the customers they must be attractive, simple, logic and beneficial.

Advanced Algorithms
"Almost Unlimited Processing Power" is a rather nerdy way to formulate a megatrend, however still a very true one. Moore's law in semiconductor technology - first described by Gordon Moore, Intel, in 1965 - still holds today, after 50 years: the number of transistors in a dense integrated circuit doubles approximately every two years.

Director's report

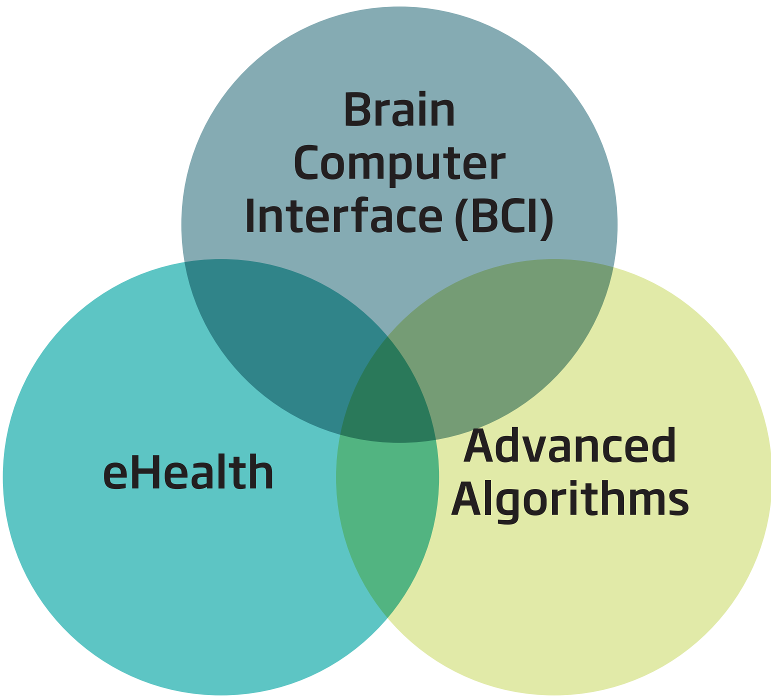
For our industry it means the capability to implement algorithms into future hearing instruments, which you might have seen in science fiction. And what do I mean by that? You may remember my quoting of Claus Elberling – pre-predecessor as the head of Eriksholm – that Eriksholm Research Center should be a little bit like Q in James Bond, free to come with incredible solutions.

Well in the James Bond movie "Tomorrow Never Dies" (1997) such a science fiction glimpse was shown, when the evil "techno-terrorist" Henry Gupta filters the conversation of Bond with Paris Carver out of a mumble of voices. The evil Mr. Carver this "techno mumbo jumbo".

In a lab environment it was known since quite a while how to do that trick. To implement this in a hearing instrument in terms of real time signal processing with restricted space and battery power was a clear no-go so far and deemed to remain science fiction.

For the hearing impaired this is however the core of their challenge: even the most modern hearing instruments still does not solve the proverbial "cocktail party syndrome". The hearing impaired still remain unable to understand competing voices, a challenge which is at the same time easy and almost effortless dealt with by a normal hearing person.

At Eriksholm Research Centre we will use these powerful "silicon engines" which Moore's law is giving us for implementing Advanced Algorithms, our third megatrend, into the hearing instruments of the future. They will enable the hearing impaired listener to filter exactly the voice he/she wants to listen to out of a mumble of many voices. Thereby an idea of a James Bond movie script will become reality.



Principal collaborations

- Ecole Normale Supérieure (ENS), Paris
  (Shihab Shamma, Alain de Cheveginé)
- Linköping University
  (Gerhard Andersson, Stefan Stenfelt, Mary Rudner, Jerker Rönnberg, Marie Öberg, Fredrik Gustavsson)
- Lund University
  (Jonas Brännström)
- Max Planck Institute, Leipzig
  (Jonas Obleser)
- National Center for Rehabilitative Auditory Research (NCRAR)
  (Gabrielle Saunders)
- Tampere University of Technology, Finland
  (Toumas Virtanen, Tom Barker)
- Technical University of Denmark
  (Rasmus Reinhold Paulsen, Torsten Dau, Sébastien Santurette, Ewen MacDonald)
- University of Colorado
  (Kathryn Arehart, James Kates, Pamela Souza)
- University College London (UCL)
  (Maria Chait)
- University of Zurich (UZH)
  (Shih-Chii Liu)
- University of Manchester, United Kingdom
  (Andrew King, Chris Plack, Piers Dawes)
- University of Auckland, New Zealand
  (Suzanne C. Purdy and Abin Kuruvilla Mathew)
- University of Southern Denmark, Participatory Innovation Research Centre (SPIRE)
  (Jacob Buur)
- Vanderbilt University, Bill Wilkerson Center, Dept. of Speech and Hearing, Nashville, Tennessee, USA
  (Benjamin Hornsby)
- VU University Medical Center, Dept. of Otolaryngology-Head and Neck Surgery, Audiology section, EMGO+ Institute, Amsterdam
  (Sophia Kramer, Adriana Zekveld)

Research activities

Brain Computer Interface

Cognitive hearing science is an emerging field of interdisciplinary research concerning the interactions between hearing and cognition.
The research area includes technology development that offers new opportunities to utilize complex digital signal processing in order to design technologies capable of addressing challenging everyday environments. Current research directions of interest to Eriksholm Research Centre include ways to assess cognitive load and attention of a listener under real-world conditions, as well as using cognitive test methods to predict and assess hearing aid outcome.

Cognitive control of a hearing aid: COCOHA

The COCOHA project revolves around a need, an opportunity, and a challenge. Millions of people struggle to communicate in noisy environments particularly the elderly: 7% of the European population are classified as hearing impaired. Hearing aids can effectively deal with a simple loss in sensitivity, but they do not restore the ability of a healthy pair of young ears to pick out one weak voice among many, which is needed for effective social communication. That is the need.

The opportunity is that decisive technological progress has been made in the area of acoustic scene analysis: arrays of microphones and beam forming algorithms, or distributed networks of hand-held devices such as smart phones can be recruited to vastly improve the signal-to-noise ratio of weak sound sources. Some of these techniques have been around for a while, and are even integrated in commercially available hearing aids. However their uptake is limited for one very simple reason: there is no easy way to steer the device, no way to tell it to direct the processing to the one source among many that the user wishes to attend to.

The COCOHA project proposes to use brain signals (EEG) to help steer the acoustic scene analysis hardware, in effect extending the efferent neural pathways that control all stages of processing from cortex down to the cochlea, to govern also the external device. To succeed we must overcome major technical hurdles, drawing on methods from acoustic signal processing and machine learning borrowed from the field of Brain Computer Interface. On the way we will probe interesting scientific problems related to attention, electro-physiological correlates of sensory input and brain state, the structure of sound and brain signals. This is the challenge.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 644732. The grant period is 2015-2019.

Collaborators are Technical University of Denmark, Ecole Normale Supérieure (ENS), University College London (UCL), and University of Zurich (UZH).

Influence of hearing impairment on alpha power during retention of auditory stimuli. PhD project
The working memory influences listening by rendering the processing and storing of the auditory input. Both external auditory degradation, e.g. background noise, as well as internal degradation, e.g. hearing loss, should affect the processing of auditory stimuli. An objective measure of the working memory can be obtained from the electroencephalography (EEG) as the alpha activity (6-12 Hz). Following the functional inhibition theory, alpha power reflects inhibition, which increases with increased working memory demands in order to shut down processes and brain areas irrelevant for solving the task at hand[1].

The effect of hearing loss, as well as background noise level and memory load, was investigated in an auditory Sternberg task[2]. Previous results show that alpha power increase during retention of the auditory stimuli with both memory load and sound degradation[3]. A total of 28 elderly participants (mean age 72.2, range 62-86) with a wide range of hearing acuity, ranging from normal to moderately impaired, were included.

The participants were presented with 2, 4, or 6 digits (memory load) embedded in one of three levels of noise. After a short silent stimuli-free period where the digits were to be retained in memory, a probe digit was presented and the participants answer whether they had heard the probe in the stream of digits. The intermediate noise condition were individualized to the speech reception threshold of 80% (SRT80, condition 0 dB SRT80), and the easier and more difficult condition generated by adding and subtracting 4 dB, respectively (denoted 4 dB SRT80 and -4 dB SRT80). All participants were wearing individually fitted hearing aids and all auditory stimuli were presented directly through the Direct Audio Input (DAI). EEG was recorded using the EGI system incorporating 128 electrodes, of which 18 electrodes were removed for technical reasons. Due to a significant correlation between age and hearing loss ($p = 0.018$), the residualized pure-tone average (denoted rPTA), quantifying the variation of PTA not explained by age was used as a measure of hearing loss.

The task accuracy showed significant effects of the memory load ($p = 0.005$) and background noise level ($p < 0.001$). Interesting, hearing loss did not significantly affect the performance ($p = 0.185$), indicating adequate hearing loss compensation and noise level individualization.

Looking at the alpha power during the retention of the auditory stimuli, we found that alpha power, independent of conditions, scales with hearing loss ($p = 0.0483$, Figure 1A). This indicates that worse hearing causes increased working memory involvement, quantified through the alpha power. Interestingly, we found that quadratic interactions between rPTA and background noise level ($p = 0.004$, Figure 1B), as well as rPTA, background noise level, and memory load ($p = 0.042$, Figure 1C). These quadratic trends indicate that for the normal to mildly impaired hearing, increased working memory load result in higher alpha power, as expected. For the moderately impaired participants, however, a decrease, or breakdown, in the alpha power was seen. We interpret this as a sign of a ceiling effect of the alpha power: The moderately impaired participants initially had higher alpha power, but with increasing working memory involvement they cannot compensate by increasing the alpha power, resulting in a breakdown. In fMRI studies a similar activity breakdown has been observed in working memory tasks with increasing age, with no consequent performance decrease[4].

We propose that, similar to increasing age, more severe hearing loss can cause neural activity breakdown as a result of having to engage more working memory resources than participants with better hearing.

Project supported by the Oticon Foundation.
Contact person: Eline Borch Petersen.

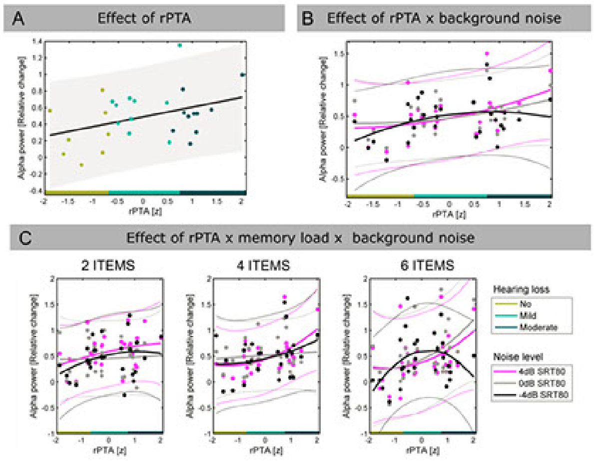


Figure 1: Hearing loss affects alpha power during the retention of auditory stimuli. (A) The significant linear relationship between alpha power and rPTA ($p = 0.048$). The regression line is shown with a solid black line, and the 95% confidence interval of the regression is shown in thin lines. The colour code on the x-axis indicates the hearing loss severity. (B) The significant quadratic interaction between rPTA and background noise level, illustrated with quadratic fits between alpha power and rPTA for each background noise level (green: 4 dB SRT80, light blue: 0 dB SRT80, and dark red: -4 dB SRT80). (C) The three panels show quadratic three way interaction memory load x background noise level x rPTA. Each panel shows one of the three memory load conditions (2, 4, and 6 items to be remembered) with alpha power as a function of rPTA with hearing loss groups indicated on the x-axis.

[1] *Klimesch, W., Sauseng, P., Hanslmayr, S., 2007. EEG alpha oscillations: the inhibition-timing hypothesis. Brain Res. Rev., 53(1), p.63–88.*
[2] *Sternberg, S., 1966. High speed scanning in human memory. Science (80-.)., 153, p.652–654.*
[3] *Obleser, J., Wostmann, M., Hellbernd, N., Wilsch, A., Maess, B., 2012. Adverse Listening Conditions and Memory Load Drive a Common Alpha Oscillatory Network. J. Neurosci., 32, p.12376–12383.*
[4] *Reuter-Lorenz, P.A., Cappell, K. a., 2008. Neurocognitive Aging and the Compensation Hypothesis. Curr. Dir. Psychol. Sci., 17(3), p.177–182.*

Research activities

LISTEN: Pupillometry as a window into listening effort and stress

Eriksholm is the private partner in an EU FP7 Marie Curie European Industrial Doctorate (EID) project (LISTEN607373) with VU University Medical Center, Amsterdam (Sophia Kramer and Adriana Zekveld) as Coordinating Partner and the Institute of Physiology and Pathology of Hearing, Warsaw (Artur Lorens) as Associate Partner.

The LISTEN project builds on the VUMC group's long experience with pupillometry (measuring the size of the eye pupil) as a way to record a person's cognitive effort from moment to moment. Fundamental characteristics of the variations in pupil dilation with signal-noise ratio, noise type, and hearing impairment have been mapped, and relevant methodological challenges have been revealed (e.g. pupil size under neutral conditions changes with age). Pupillometry studies have already shown that the relations between cognitive capacity, objectively measured listening effort, and speech-in-noise performance are more complex than initially thought. In the LISTEN project, these discoveries are being extended in two main directions: Firstly, to examine the effect of alternative signal processing schemes in hearing aids on objective listening effort, and secondly, to consider a new dimension potentially accessible via pupillometry, namely the long-term (chronic) stress induced by hearing loss.

While cognitive exertion affects pupil size via the sympathetic nervous system (more exertion resulting in larger dilation of the pupil), stress affects it via the parasympathetic system (more stress resulting in less constriction of the pupil due to light exposure). Thus, the pupil size at any given moment reflects the balance of activation between the two systems. Experiments in LISTEN aim to unravel the contributions from the two sources and correlate them with subjectively experienced listening effort and stress in daily life.

In 2014 two PhD students, Barbara Ohlenforst and Yang Wang, have joined the project and they are making good progress on the initial stages. Ethical clearance has been obtained for all the experiments which are planned to take place in Amsterdam, literature reviews are almost complete, and pilot experiments are well underway. The PhD students will move to Eriksholm in September 2015. Funding for the fourth year of these Dutch PhD projects has been obtained from the Oticon Foundation. The project will continue until 2017.

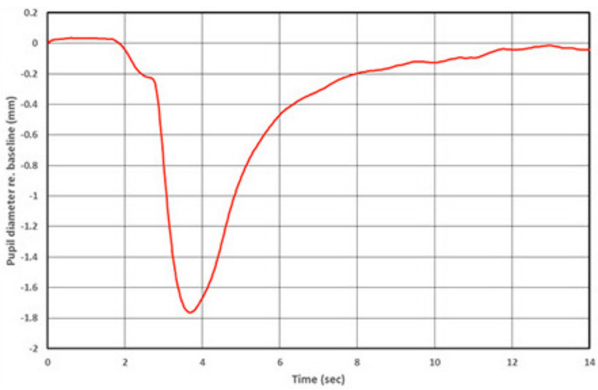


Figure 2: Pilot data on Pupillary Light Reflex (PLR). The light flash starts at approx. time = 1 second. Data averaged across several subjects, flash durations and light colours.

The ultimate goals are to develop tools and methodologies for objectively evaluating listening effort
to clarify relations between innate cognitive capacity, task difficulty and expended listening effort
to document the degree to which different hearing aid systems may affect listening effort
to elucidate connections between short-term listening effort and long-term stress in daily life.

Contact persons:
Graham Naylor, Thomas Lunner.

Pupillometry as an objective measure for listening effort during speech perception

Understanding speech is a complex process that is influenced by a number of factors involving both the sensory and the cognitive domain. Several studies report that in addition to the participant's hearing thresholds his or her cognitive abilities, like working memory capacity and attention, play an important role[1]. An acoustically degraded speech signal can lead to a larger demand on cognitive processes when recovering lost speech information in order to achieve speech comprehension[2,3,4]. As a consequence, cognitive load increases when processing noisy speech. The pupil dilation response has shown to be an objective measure of processing load in several cognitive demanding tasks5. In general, a larger pupil response is associated with higher cognitive load. Previous studies already reported that processing load may change depending on the background noise, even if speech intelligibility remains constant. Koelewijn and colleagues showed that the pupil dilation response was sensitive to different types of background noise[6,7]. For normally hearing and hearing impaired participants, they were able to show that pupil size increases when processing speech in the presence of a competing talker compared to processing speech in fluctuating noise. Thus, pupillometry provides objective measures in order to quantify cognitive processing load for speech perception in noise (listening effort) even at controlled and high speech intelligibly levels.

This project aims at validating the pupillometry method, proposed by Koelewijn and colleagues, with Danish HINT sentences[8]. The objective of this project is to reproduce the results reported by Koelewijn et al. and to investigate the effect of masker type on cognitive load when processing Danish sentences. Pupil dilation is measured at controlled intelligibility levels (at 50% and 84% intelligibility) with fluctuating noise and with a competing talker (with different gender). In addition, pupil dilation is measured in the presence of 4-talker-babble (2 female and 2 male talkers). The effect of masker type on cognitive processing load during sentence processing is investigated for normally hearing participants.

If the validation of the pupillometry paradigm with Danish language is successful, a further goal is to examine the effect of alternative signal processing schemes in hearing aids on objective listening effort using pupillometry. This project is performed in cooperation with the VU University Medical Center in Amsterdam (Sophia Kramer, Adriana Zekveld, Thomas Koelewijn, Hans van Beek).

Project supported by the Oticon Foundation.
Contact person: Dorothea Wendt.

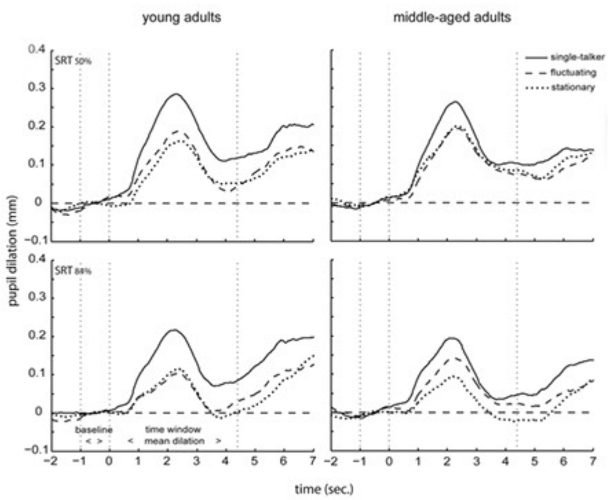


Figure 3: Average pupil response over subjects per condition for two different age groups. The onset of the speech is at 0 sec. The area between the second and third dotted lines indicates the time window used for calculating the mean pupil dilation (from Koelewijn et al., 2012[6]).

[1] *Akeroyd, M.A. (2008). Are individual differences in speech reception related to individual differences in cognitive ability? A survey of twenty experimental studies with normal and hearing-impaired adults. Int J Audiol, 47(2), 53-71.*
[2] *Pichora-Fuller, M.K., Schneider, B.A. & Daneman, M. (1995). How young and old adults listen to and remember speech in noise. J Acoust Soc Am, 97, 593-608.*
[3] *Zekveld, A.A., Kramer, S.E., & Festen, J.M. (2010). Pupil response as an indication of effortful listening: the influence of sentence intelligibility. Ear Hear, 31, 480-490.*
[4] *Rönnberg J. , Rudner M. , Foo C. & Lunner, T. (2008). Cognition counts: a working memory system for ease of language understanding (ELU). Int J Audiol, 47(2), S99-S105.*
[5] *Beatty, J. (1982). Task-evoked pupillary responses, processing load, and the structure of processing resources. Psychol Bull, 91, 276-292.*
[6] *Koelewijn, T., Zekveld, A.A., Festen, J.M., & Kramer, S.E. (2012). Pupil dilation uncovers extra listening effort in the presence of a single-talker masker. Ear Hear, 33, 291-300.*
[7] *Koelewijn, T., Zekveld, A.A., Festen, J.M. & Kramer, S.E. (2014). The influence of informational masking on speech perception and pupil response in adults with hearing impairment. J Acoust Soc Am, 135(3), 1596-1606.*
[8] *Nielsen, J. B. & Dau, T. (2011). The Danish hearing in noise test. Int J Audiol, 50(3), 202-208.*

Research activities

Cognitive Spare Capacity

The main focus for 2014 has been to finalize measures for Cognitive Spare Capacity (CSC), where spare capacity refers to the residual capacity after successful recognition. The purpose with development of CSC testing is to find new cognitive based assessment methods that are sensitive in signal-to-noise ratios (SNRs) where traditional speech-in-noise methods are insensitive. The PhD students Sushmit Mishra (S8) and Niklas Rönnberg (S9) successfully defended their PhD theses during 2014.

The concept of cognitive spare capacity was also the focus of a journal club review by the Hearing Journal.

Sentence-final Word Identification and Recall in new Language: SWIRL

Working memory is important for online language processing in a dialogue. We use it to store, to inhibit or ignore what is not relevant, and to attend to things selectively. The Ease of Language Understanding (ELU) model describes the role of working memory capacity (WMC) in complex listening situation and with hearing impairment to explain findings on e.g. the relationship between WMC and speech signal processing and short-term retention. A poor representation of a signal in the neural pathways will, according to the ELU-model, lead to activations of the (effortful) working memory system. In the presentation it was argued that hearing impaired persons must rely much more on effortful working memory resources to understand what has been said, compared to normal hearing persons that can rely more on effortless highly over learned automatic speech recognition systems, and that this is a reason to why the hearing-impaired become exhausted after a day of listening.

Performance of hearing aid signal processing is often assessed by speech intelligibility in noise tests, such as the HINT sentences presented in a background of noise or babble. Usually such tests are most sensitive at a signal-to-noise ratio (SNR) below 0 dB. However, in a recent study by Smeds et al.[1] (in press) it was shown that the SNRs in ecological listening situations (e.g. kitchen, babble, and car) were typically well above 0 dB SNR. That is, SNRs where the speech intelligibility in noise tests are insensitive. Therefore new measures are needed that can show eventual benefits of hearing aid processing in the + 5-15 dB range.

Cognitive Spare Capacity (CSC) refers to the residual capacity after successful speech perception. In a recent study by Ng et al.[2], the residual capacity was defined to be the number of words recalled after successful listening to a number of HINT sentences, inspired by Sarampalis et al.[3]. In two recent studies with 26 and 25 hearing impaired test subjects, respectively, we showed that close to 100% correct speech intelligibility in a four talker babble noise required around + 7-9 dB SNR. At that SNR it was shown that a hearing aid noise reduction scheme improved memory recall by about 10%. Thus, this kind of memory recall test is a possible candidate for assessment of hearing aid functionality in ecologically relevant (positive) SNRs.

Contact person: Thomas Lunner.

[1] Smeds K, Wolters F, Rung M. (In press).Estimation of signal-to-noise ratios in realistic sound scenarios. Journal of the American Academy of Audiology, 26, 183-96. doi: 10.3766/jaaa.26.2.7.
[2] Ng EHN, Rudner M, Lunner T, & Rönnberg J. Noise reduction improves memory for target language speech in competing native but not foreign language speech. Ear and hearing, 36, 82-91.
[3] Sarampalis, A., Kalluri, S., Edwards, B., et al. (2009). Objective measures of listening effort: Effects of background noise and noise reduction. J Speech Lang Hear Res, 52, 1230–1240.

Taxonomy of concepts and knowledge review relating to listening-related fatigue

The audiological community is beginning to look beyond speech intelligibility towards higher-level phenomena, both with respect to the problems created by hearing impairment, and for outcome measures demonstrating the benefits of hearing aids. Listening effort has already attracted considerable attention, but listening effort is not the whole story regarding the cognitive costs of difficult listening. Listening effort occurs here-and-now as cognitive resources are applied to comprehend auditory inputs. When the job is done, listening effort returns to zero.

However over a longer period of time, the consequences of exerting listening effort may be experienced as fatigue. Fatigue may thus be a serious consequence of hearing loss, and may potentially be reduced by appropriate hearing aid fitting. Before we can use fatigue as a concept in our armoury for research and development, the nature of fatigue needs to be clarified as much as possible.

This project draws on the extensive fatigue literature from other health fields, to explain the different varieties of fatigue and how they may be measured. Furthermore, it collects the latest knowledge on fatigue relating to hearing impairment, and identifies fruitful areas for further research to focus on. The first (review) part of this project has been carried out by Dr. Benjamin Hornsby of Vanderbilt University, Nashville, Tennessee, USA.

While there are enormous bodies of research on fatigue relating to serious diseases, safety at work, and athletic performance, very little is known about fatigue and hearing difficulty. However it is clear that hearing impairment can lead to symptoms of chronic general and mental fatigue (e.g. need for recovery after the day at work or school). Physical fatigue appears to be less relevant.

Methods for provoking and measuring short-term (acute) listening-related fatigue are not yet mature; it is still far from clear how to establish parameters of experiments for reliable results.

Many models of fatigue have been proposed, with their perspectives varying from biological processes at the cellular level to disembodied phenomenological models. So far, no widely accepted models exist which are helpful to our particular type of interest.

So far there exists no robust evidence that the use of hearing aids reduces chronic fatigue, although preliminary results indicate that it can reduce acute fatigue, at least under certain circumstances.

The following research priorities have been identified by this project:

- Do hearing aids decrease chronic fatigue ?
- What are the relations between acute and chronic listening-related fatigue ?
- Methods for reliable elicitation and measurement of acute listening-related fatigue
- What features of a sound make it effortful to listen to ?

This project has been completed in 2014.
Contact person: Graham Naylor.

eHealth

eHealth is a broad interdisciplinary area centred around the use of information and communication technologies (ICT) for health. In its broadest sense, eHealth improves the flow of information, through electronic means, to support the delivery of health services and the management of health systems. At the Eriksholm Research Centre, we conduct eHealth research that delivers documented scientific insights and clinical methods which can be deployed in an efficient way to improve hearing treatment. We are currently especially active in researching eHealth-supported interventions that result in improved help-seeking for hearing impairment, greater hearing aid usage, and better hearing aid outcomes.

Internet tools for hearing care professionals and their users

There is a high prevalence of internet use, including in people with hearing impairment. Eriksholm develops and tests internet methods and interventions for hearing care professionals and their users.

Online audiological rehabilitation

The aim of the Online audiological rehabilitation (OAR) study is to further develop and extend the online rehabilitation research started at the Eriksholm Research Centre and described in Thorén et al 2011[1]; 2014[2].

We know from earlier research that the most common treatment for hearing loss includes hearing aids. We also know that today's advanced hearing aids are helpful, but even modern hearing aids cannot provide complete rehabilitation. We also *know that of those who own/use hearing aids, not all benefit from them. Using the internet in the audiological rehabilitation process might be a cost-effective way to include additional rehabilitation components by guiding hearing-aid users on topics such as communication strategies, hearing tactics and how to handle hearing aids. An OAR program might foster behavioural changes that will positively affect hearing-aid users.*

The OAR program in this study aims at systematically comparing the clinical effectiveness of four different versions of an online rehabilitation program; a standardised OAR program versus a tailored OAR program and a short (2-week) OAR program versus a long (5-week) OAR program.

The OAR study includes a development phase as well as an evaluation phase. During 2014, the project was started up and the development phase was initiated. During 2015, the evaluation phase is planned to kick off and the OAR programs will be tested in English-language countries in typical hearing aid clients.

The project continues in 2015. The OAR project is partly funded by the Oticon Foundation. Contact person: Elisabet S Thorén.

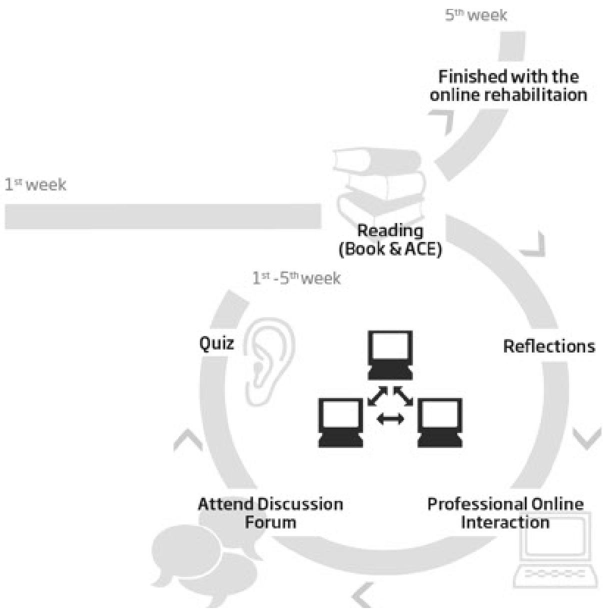


Figure 4. The outline of previously evaluated online education program with the included weekly elements; reading, reflections, online interaction with audiologist, online interaction with peers and quiz.

[1] Thorén ES, Svensson M, Törnqvist A, Andersson G, Carlbring C, Lunner T. (2011). Rehabilitative Online Education versus Internet Discussion Group for Hearing Aid Users: A Randomized Controlled Trial. J Am Acad Audiol, 22, 274–285.

[2] Thorén ES, Öberg M, Wänström G, Andersson G, Lunner T. (2014). A randomized controlled trial evaluating the effects of online rehabilitative intervention for adult hearing-aid users. International Journal of Audiology, 53, 452-61.

From detection to intervention. Reaching and treating persons with hearing disorders, using modern information technology
Ariane Laplante-Lévesque and Thomas Lunner, in their part-time appointments at Linköping University in Sweden, collaborate on a research programme with Gerhard Andersson ("From detection to intervention. Reaching and treating persons with hearing disorders using modern information technology").

In 2014, Ariane and Thomas contributed to a randomised controlled trial of motivational interviewing over the internet for adults who fail an online hearing screening. Collaborators on this study include Sandra Weineland, Elisabeth Ingo, Peter Molander, Hugo Hesser (Linköping University, Sweden), Peter Nordqvist (Forskningsinstitutet Hörselbron, Sweden), and Per Carlbring (Karolinska Institutet, Sweden).

Contact person: Ariane Laplante-Lévesque.

Dispensing processes with relevance to eHealth

eHealth solutions must address the needs of hearing care professionals and their users throughout the dispensing process. Therefore, Eriksholm studies dispensing process, both from the perspectives of hearing care professionals and of users, with the aim to identify relevant future eHealth solutions.

Promotion of trust in hearing healthcare services delivery
This study analyses hearing aid clients' trust in hearing health care service delivery from interviews conducted in four countries. Trust in hearing healthcare services delivery is described according to four dimensions. In 2014, we disseminated the results of the study: one manuscript was accepted for publication and two poster presentations were given. Trust is also a determining factor for the uptake of remotely-delivered hearing health care services.

Contact: Ariane Laplante-Lévesque.

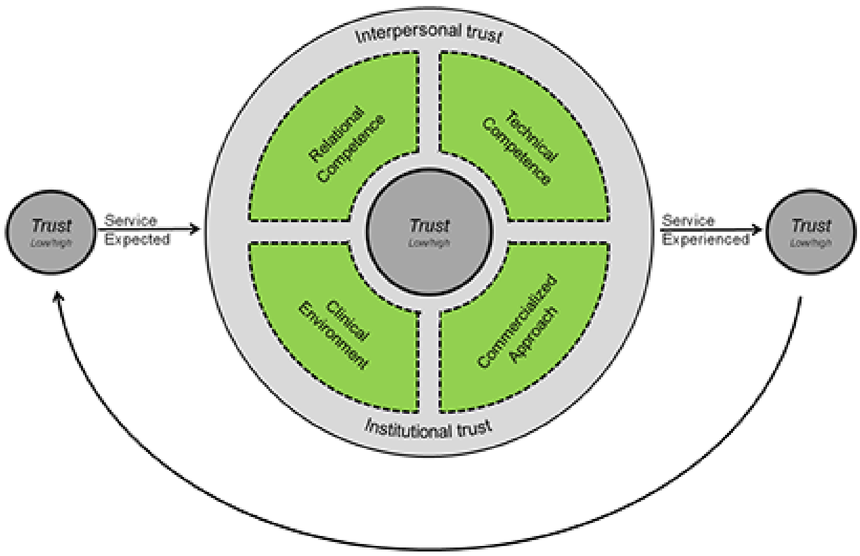
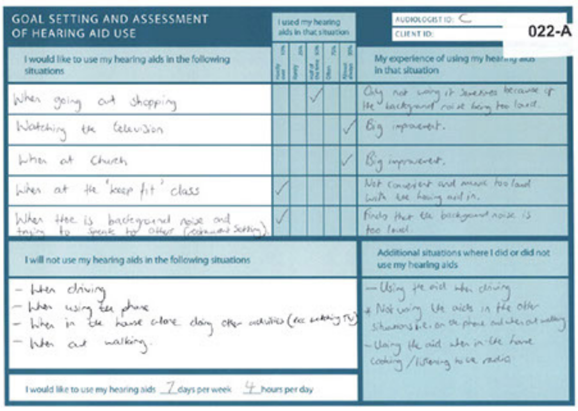


Figure 5. A Visual Representation of the Four Dimensions of Trust: The four Components of Trust(Relational Competence, TEchnical Competence, clinical Environment, and Commercialised Approach), the Type of Trust (Interpersonal vs. Institutional), the Level of Trust (low to high), and the Time Course of Trust.

Research activities

Tool for hearing aid use goal setting and assessment
This study develops and tests a tool that facilitates hearing aid use goal setting and assessment in a clinical audiological setting. The tool incorporates the knowledge gained from two previous studies of hearing aid use conducted at Eriksholm Research Centre: What is optimal hearing aid use? and Differences between self-reported and data-logged hearing aid use time.

The tool takes into account the individual needs of the client, hearing aid use amount, and patterns of hearing aid use in 1) a hearing aid use goal setting sheet and 2) a hearing aid use logbook.


GOAL SETTING AND ASSESSMENT OF HEARING AID USE

AUDIOLOGIST ID: C
CLIENT ID: 022-A

I would like to use my hearing aids in the following situations	I used my hearing aids in that situation	My experience of using my hearing aids in that situation
When going out shopping	✓	Only not using it sometimes because of the background noise being too loud.
Watching the television	✓	Big improvement.
When at Church	✓	Big improvement.
When at the 'keep fit' class	✓	Not convenient and music too loud with the hearing aid in.
When there is background noise and trying to speak to other (restaurant setting).	✓	Finds that the background noise is too loud.

I will not use my hearing aids in the following situations
- When driving
- When using the phone
- When in the house alone doing other activities (i.e. watching TV)
- When out walking.

Additional situations where I did or did not use my hearing aids
- Using the aid when driving
* Not using the aids in the other situations i.e. on the phone and when out walking
- Using the aid when in the house cooking / listening to the radio

I would like to use my hearing aids 7 days per week 4 hours per day

Figure 6. Tool for hearing aid use goal setting and assessment.

In 2014, the tool supported hearing aid fitting and follow-up appointments between audiologists and their adult clients in two audiology clinics. More specifically, four audiologists utilised the tool with 26 clients in a public clinic in the UK and two audiologists utilised the tool with 8 clients in a private clinic in Canada. Audiologists rated the tool as significantly more helpful and convenient with first-time clients than with experienced clients. Client age was inversely correlated with the audiologists' rating of the helpfulness and the convenience of the hearing aid use goal setting sheet. Further development of such clinical tools could focus on younger first-time hearing aid users and on digital solutions such as applications.

Contact person: Claus Nielsen.

Health behavior change in adults seeking hearing help for the first time
This project studies health psychology, and more specifically health behavior change (HBC), in adults seeking hearing help for the first time. The project focuses on the Health Belief Model (HBM) and the TransTheoretical Model (TTM), two well-known models of health behavior change. This project establishes evidence for the utility of the two HBC models in hearing care for describing HBC in adults who seek hearing help for the first time, and for supporting an intervention to optimise health behavior change (hearing aid uptake and hearing aid outcomes). This project includes two parts.

Part 1 is an observational study. It assesses beliefs about hearing aid rehabilitation of adults seeking hearing help for the first time, and examines how these relate to health behaviors. It aims to do so by health belief profiling, based on the HBM and the TTM. During 2013-2014, over 180 adults seeking hearing help for the first time were recruited.

Part 2 is an intervention study. In 2014, we developed an intervention based on the findings of Part 1 with the aim of increasing positive beliefs about hearing aid rehabilitation and health behavior change in adults with hearing impairment who are yet to seek help. A total of 100 adults are to be recruited in 2015.

Dr. Gabrielle Saunders from the National Center for Rehabilitative Auditory Research (NCRAR) in Portland, OR, US and her team are close collaborators on this project. They recruit participants and collect data in the Portland, OR area. As a next step, positive beliefs about hearing aid rehabilitation could also be increased via websites, applications, and other eHealth-related media.

Contact person: Ariane Laplante-Lévesque.

Innovating with pre-users of medical devices
This project is a collaboration between Oticon, Novo Nordisk and the SPIRE institute at University of Southern Denmark. The project takes the form of two parallel industrial PhD studies. The companies involved share an interest in why people who suffer from gradual hearing loss or diabetes type 2 delay starting to use treatment technologies that could medically benefit them.

The project has involved ethnographic fieldwork in clinics and private homes in Denmark and the USA, including recordings of 23 hearing care professionals in action in 77 consultations and participant observation of many more. 31 pre-users have been interviewed after their consultation, and 21 pre-users have been visited in their homes. Finally, the project has involved 6 design workshops with pre-users.

The original idea behind the project was to identify the barriers to use, and to develop design concepts to reduce these barriers. Along the way, focus has moved away from the concept of 'barriers to starting treatment', and towards how the disease becomes articulated as problematic and requiring treatment. Thus the focus is more on what people do, and less on what they do not do. For the ethnographic element of the project, this means illuminating the pre-user's relations to health professionals, family, disease and 'measurement' (both diagnostic and self-monitoring).

During 2014 PhD student Ditte Nissen Storgaard has completed and submitted her PhD thesis, thus bringing the overall project to completion.

This project was supported by a grant from the Oticon Foundation. Contact person: Graham Naylor.

Research activities

Advanced Algorithms

Hearing care is about to enter the future of unlimited and distributed computer power. In the near future hearing devices interact seamlessly with smartphones and cloud computing utilizing external computational power as co-processors to deliver yet unseen audiological benefits. However, the benefits do not come automatically. Our approach is similar to that of medical doctors. We need a diagnosis to treat optimally, as the quality of the subsequent treatment follows from the ability to diagnose. Eriksholm is determined to achieve breakthroughs by continuously expanding our knowledge about hearing-impaired listeners and their specific problems. Knowledge about the problems is followed by exploring the technical opportunities regardless if these are provided by massive computational powers or not. In particular, we aim to bridge the gap between hearing devices' capabilities and hearing-impaired listeners' specific needs. Here we take advantage of our unique position in the middle of end-users, hearing care professionals, academia, and the development of future hearing device platforms, to deliver the beneficial solutions that hearing care professionals will tailor to the individual end-user.

The following sections describe our current projects, addressing unsolved problems in modern hearing care: separation of competing voices, perception and utilization of spatial cues, and general sound quality.

Competing voices

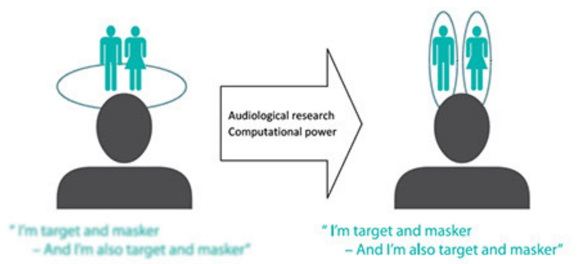


Figure 7: The present situation in hearing care where hearing-impaired listeners cannot segregate closely spaced competing voices and our vision of future hearing care where the hearing devices enable the listener t o segregate closely spaced competing voices.

End users often complain that hearing devices provide less help in competing voices situations compared to simpler listening conditions with a single voice in noise. Competing voices problems arise frequently, when watching television with a spouse, attending family dinners, while shopping, and of course at the cocktail party. Their problem, as sketched in Figure 7, is still not solved since the individualized amplification from hearing devices does not enable the end user to perceive the individual characteristics that make voices distinguishable. Eriksholm's effort to solve this problem follows from our general approach; we need to understand the problem to solve it. Therefore, we developed a competing voices test, a speech recognition test where the voices have equal importance to investigate how listeners perform and measure benefits of audiological concepts. Our competing voices test differs from traditional speech-on-speech testing by not telling the test subject which voice to report before playback. The competing voices test is a valuable tool that serves the two purposes: investigating hearing loss and measuring potential benefits of audiological concepts.

In collaboration with Tampere University of Technology, we have also investigated separation of competing voices.

Our competing voices test differs from traditional speech-on-speech testing by not telling the test subject which voice to report before playback. The competing voices test is a valuable tool that serves the two purposes: investigating hearing loss and measuring potential benefits of audiological concepts.

Separation of known voices
This collaboration with Technical University of Tampere implemented a voice separation algorithm based on knowledge about each voice. One of the key components for providing audiological benefits in competing voices situations is voice separation. Initially, the benefit of such algorithms arises in situations with relatives, teachers, and colleagues – people that would probably spend a few minutes teaching the hearing device their voice. However, in the longer perspective, the goal of this research is to develop hearing devices that quickly learn peoples' voice and thereafter separates them from other voices.

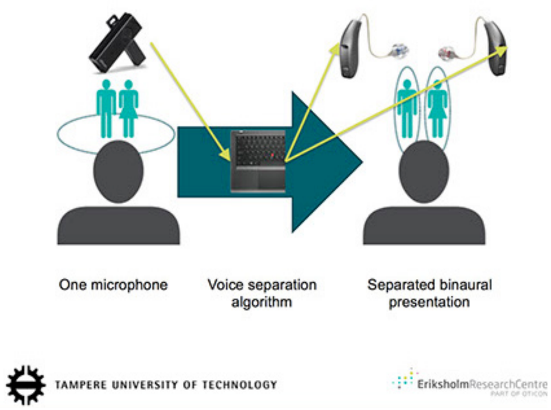


Figure 8: Demonstration of the known voices separation algorithm. The single microphone to the left picks up the two voices (click on single_microphone sound clip to the left). In the middle, the voice separation algorithm separates the two voices, using only 20 seconds of previously recorded sentences with each voice. To the right the two separated voices are presented in each ear (click on separated_binaural_presentation sound clip to the left).

PhD Student Tom Barker.
Contact person: Niels Henrik Pontoppidan.

Development of a competing voices test

In 2014, our focus was on developing a suitable test to measure hearing-impaired listeners' performance in a true competing-voices situation. Such tests are not available as standard tests today, and hence a new test was to be designed and developed more or less from scratch. We used existing speech material as the starting point. The main purpose was to develop a test that reflected a true competing voice situation with two equally important target speakers, whilst also allowing for successfully testing with elderly hearing-impaired listeners.
In the study, Competing voices test 1.0, three different test paradigms were investigated with hearing-impaired listeners as shown in Figure 9:

Sentence on story: An audio story is being presented in one ear. The story must be remembered. At the same time, sentences are presented in the other ear. These sentences must be repeated orally by the listeners, to achieve a % words correct score. The two talkers are always opposite gender (male and female).

Dual sentences: Two sentences of different types are presented simultaneously, one in each ear. In the first version, the Danish Hearing In Noise Test (HINT) (Nielsen & Dau, 2011) male speech was used in one ear and the Dantale 2 (Wagener et al, 2003)[1] female speech was used in the other ear. The listener should repeat the male, female or 'both' sentences. In the cases 'male' and 'female', the target talker was indicated to the listener on a PC monitor in front of him. This cue could be presented before ('pre'), after ('post') and during ('both') the sentence playback, where 'pre' is the ordinary test condition for speech on speech testing.

Dual stories: Two audio stories, read by a male and female, respectively, are being presented simultaneously, one in each ear. The listener has a sheet with the text from the stories, alternating from one story to the other as indicated by colour in the text. Certain words are missing in the test, and the task of the listener is to hear these words and write them down in the paper sheet.

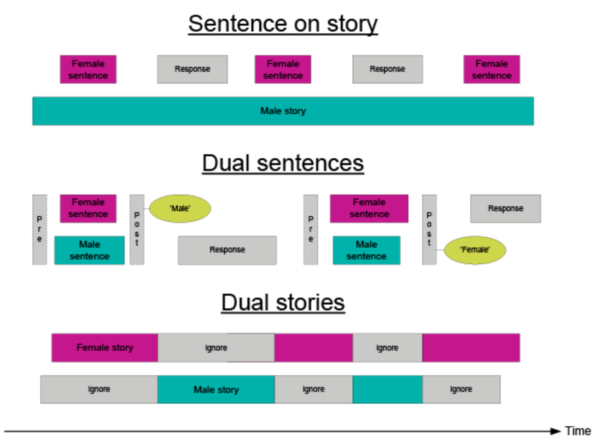


Figure 9: Illustration of the timeline of the three competing voice paradigms tested in study 1.0.

The 1.0 study indicated that 'Dual sentences' was the best test paradigm for further development. The speech recognition scores were around the 50% range, where a speech test is most sensitive. Two attributes of the test, difficulty and similarity to real life, were rated by the listeners on a 1-10 scale to assess the difficulty and relevance of the test. These results are shown in Figure 10. The dual sentences score in the 5-8 range (5='Acceptable', 7='Hard', 9 = 'Very hard') were found acceptable for further work.

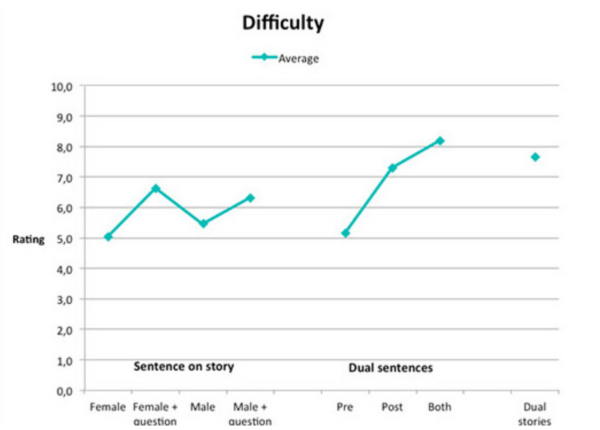


Figure 10: Average difficulty ratings for the different test paradigms in test 1.0.

A summary of study 1.0 can be found in (Bramsløw et al, 2014)[2].

In the following study 'Competing voices test 1.1', the Dual sentences test was explored further – to determine best use of pre/post/both cue and to assess the sensitivity of the test – by attempting to detect different binaural stimulus modes. The test was changed to use HINT sentences for both the male and female voice, which could be done by recording the Danish HINT sentences with a female voice and combining these with the existing male HINT sentences. Different cue placements and spatial conditions were used and significant effects were found from both factors.

The effect of cue is shown in Figure 11: 'pre' is rather easy at 74% correct, compared to 'post' and 'both' at 51% and 49%. Only the two later require dual attention to both sentences.

The future recommendation is to use 'post' cueing as it forces dual attention and is faster to score than 'both'.

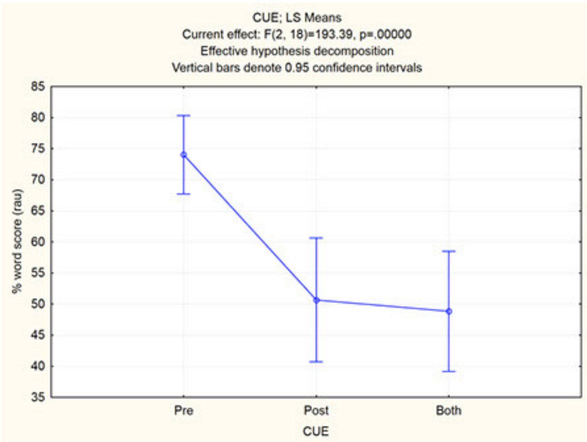


Figure 11: Effects of cue timing on word recognition score.

The three binaural modes were added to the experiment to assess the test sensitivity to these rather gross binaural cue changes:

- Separate: Each talker is in one ear.
- Sum: The two talkers are summed
- and presented to both ears.
- Male_reverse: Both talkers are presented to both ears as for 'sum', but the male talker is phase reversed to one ear, to test if this provides any binaural unmasking.

The binaural results shown in Figure 12 show a clear and statistically significant effect of the 'separate' mode compared to the other two modes. The 'male_ reverse' mode does not have a statistically significant score higher than the 'sum' mode, so this does not provide any binaural unmasking.

A summary of study 1.1 can be found in (Bramsløw et al, 2015)[3].

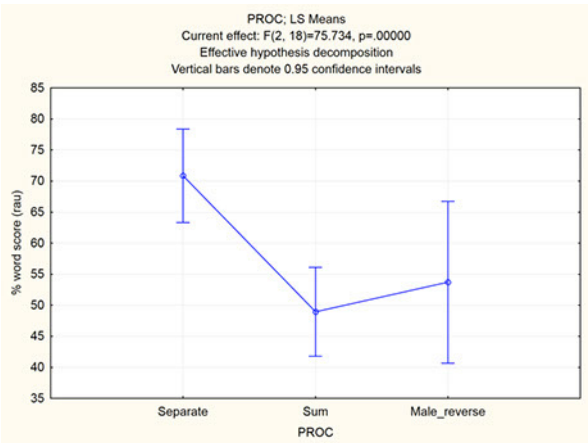


Figure 12: Effects of the three binaural modes on word recognition score.

Contact person: Lars Bramsløw.

[1] *Wagener, K., Josvassen, J.L., Ardenkjaer, R., 2003. Design, optimization and evaluation of a Danish sentence test in noise. Int. J. Audiol., 42, p.10–17.*

[2] *Bramsløw, L., Vatti, M., Hietkamp, R., Pontoppidan, N.H., 2014. Design of a competing voices test. In International Hearing aid Conference (IHCON) 2014. Lake Tahoe, CA, USA, p. 1. Available at: http://www.eriksholm.com/about-us/news/IHCON_2014.*

[3] *Bramsløw, L., Vatti, M., Hietkamp, R.K., Pontoppidan, N.H., 2015. Binaural speech recognition for normal-hearing and hearing-impaired listeners in a competing voice test. In Speech in Noise 2015. Copenhagen, p. 1. Available at: http://www.eriksholm.com/about-us/news/2015/SPIN_2015.*

Enhanced pinna cues for hearing-aid users

The human pinna introduces spatial acoustic cues in terms of direction-dependent spectral patterns of peaks and troughs that shape the incoming sound. These cues are specifically useful for localization in the vertical dimension and for resolving front-back confusions. Salient pinna cues exist in the frequency range 5-16 kHz, a frequency range where people with hearing loss typically have their highest hearing thresholds.
Since increased thresholds are often accompanied by reduced frequency resolution, there are good reasons to believe that many people with hearing loss are unable to discriminate the subtle spectral pinna-cue details, even if the relevant frequency region were amplified by hearing aids. In addition, natural pinna cues extend far beyond the current 10-kHz audio bandwidth of hearing aids.

One potential solution to these problems is to provide hearing-aid users with artificially enhanced pinna cues – as if they were listening through oversized pinnas. In the present study, it was tested whether or not listeners were better at discriminating spectral patterns similar to enlarged-pinna cues. The enlarged patterns were created by transposing (T) generic normal-sized-pinna cues (N) one octave down. The experiment was cast as a simulated determination of minimum audible angle (MAA) in the median saggital plane, using a three-alternative forced choice (3AFC) paradigm. 13 listeners with sloping hearing loss and 11 normal-hearing listeners participated. The results are summarized in Figure 13. Here it is seen that the normal-hearing listeners showed similar discrimination performance with the T and N-type simulated pinna cues, as expected. Contrary to expectations, the results for the hearing-impaired listeners showed only marginally lower MAAs with the T-cues compared to the N-cues, and the overall discrimination thresholds were much higher for the hearing-impaired compared to the normal-hearing listeners.

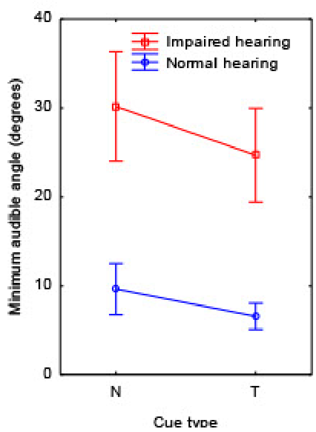


Figure 13: Minimum audible angles (simulated) for the two types of enhanced pinna cues (N: normal, T: transposed) in the two listener groups. Weighted means and 95% confidence intervals are shown.

Research activities

These results do not suggest that the vertical-dimension localization ability of hearing-aid users can be restored to normal. However, the results indicate that it may be possible to provide hearing-aid users with enhanced pinna cues in a (lower) frequency range, which is within the audio bandwidth of current hearing aids. It should be noted that the present study only addresses discrimination thresholds; another question is whether hearing-aid users can learn to exploit the enhanced pinna cues for localization purposes. This is subject to future work.

Contact person: Søren Laugesen.

End-user benefits from individualized acoustical transforms in hearing aids

When a person is listening (unaided), sounds are coloured by the head, the pinna, and the ear canal. When a hearing aid is placed in the ear, these natural colorations are changed. To compensate for this, all hearing aids employ certain acoustical transforms*.

In most hearing-aid fittings standardized transforms are used, such that sounds are artificially coloured in a way corresponding to an average ear. However, the individual natural colorations can deviate substantially from the average. It is well known that for the individual, such deviations can cause a mismatch between the hearing aid's target gain and the actual gain achieved (see Figure 14), which can result in audibility issues. However, there are other outcome domains that might be affected, e.g. sound quality. In any case, the potential self-perceived end-user benefits of using individualized acoustical transforms in hearing aids are greatly under-explored.

The main purpose of this project is to investigate whether using individualized acoustical transforms, as compared to using standardized acoustical transforms, has the potential to provide significant end-user benefits.

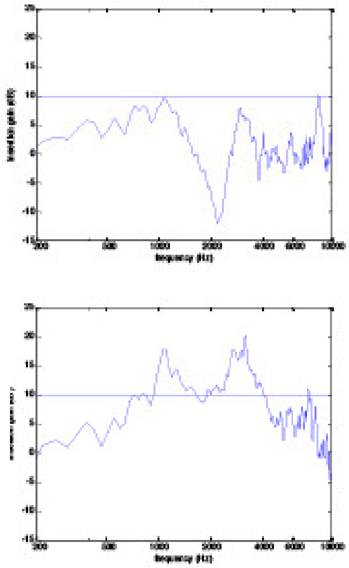


Figure 14: Real-ear insertion gain measured in a typical male (left) and female (right) ear, with the nominal 10-dB insertion gain indicated by the dashed line.

Individual acoustical transforms can be measured in the clinic by using Real Ear Measurement (REM) equipment, and these measurements can be used to individualize the hearing-aid fitting. An additional purpose of the project is to examine the validity and reliability of clinical REMs.

The activities in 2014 have focused on creating a set-up for 'golden standard' REMs, using laboratory-grade equipment in the anechoic room. In addition, the first perceptual experiment has been prepared and piloted. In this experiment, normal-hearing listeners will compare listening through individualized versus standardized acoustical transforms in terms of sound quality. The project continues in 2015.

Examples of music samples processed according to the dashed and solid lines in figure BAT1 can be found to the left. These examples showcases the kind of sound-quality differences one can experience between individualized versus standardized acoustical transforms.

If significant end-user benefits from using individualized acoustical transforms can be demonstrated, the results from the project can be used to promote the use of REMs in clinics – today only 25% of all fittings include REMs.

** MLE: Microphone Location Effect, OEG: Open Ear Gain, and RECD: Real Ear to Coupler Difference.*

Contact person: Søren Laugesen.

Listener characterization

Expanding our knowledge about listeners and their problems provide insights for our future work. Our current activities cover an exciting range of activities from investigating relationships between hearing aid fitting and outcomes in large groups of hearing impaired listeners, over investigating the individual relationships between relatively simple psychoacoustic measures and real-world listening abilities, to using cameras to estimate the individual acoustics due to head and ear shapes.

Patient characteristics and hearing aid satisfaction – a retrospective data analysis

This project is being carried out in collaboration with Dr. Gabrielle Saunders at the National Center for Rehabilitative Auditory Research (NCRAR), Portland, Oregon, part of the US Dept. of Veterans Affairs (VA). Audiological clinics in the VA carry out over 50,000 hearing aid fittings every year, in an environment where the electronic archiving of diverse items of patient information and follow-up data is routine. This provides an unusual opportunity for the exploration of relations between the characteristics of patients, aspects of their treatment, and outcomes. At the same time, the VA healthcare system endeavours to maximize efficiency; this implies both improved clinical outcomes and optimally efficient use of clinical effort. We hope that this project may contribute new knowledge to this goal.

The objective of this study is to ascertain whether there are identifiable sub-populations of VA patients whose hearing aid treatment outcomes deviate substantially from the population mean. To achieve this goal we are combining data from several VA databases to identify all patients with a hearing aid fitting appointment between April 2012 and October 2014. We will extract demographic, health and utilization of audiology service information regarding these patients, and will obtain data regarding their corresponding hearing aid treatment and outcome.

The principle outcome measures we will examine include:

- Scores on the seven subscales of the IOI-HA (administered as a standard part of the VA audiological protocol)
- Continued battery re-ordering one year after the hearing aid fitting (as a proxy for long-term continued hearing aid use)
- Number of interactions with a VA Audiology clinic (in person or by telephone)

Predictor variables will include:

- Audiometric data
- Demographics, including (for example) distance between home and VA audiology clinic
- Co-morbid medical conditions
- Previous hearing aid experience

Amongst our putative hypotheses are the following:

- ‘Difficult to fit' audiometric configurations (e.g. ski-slope losses) are associated with poorer outcomes (lower IOI-HA scores, more clinical interactions, discontinued hearing aid use)
- Serious co-morbidities are associated with poorer outcomes (discontinued use)
- Previous hearing aid experience is associated with better outcomes (higher IOI-HA scores, fewer clinical interactions, continued hearing aid use)

Activities in 2014 have included project start-up, attainment of ethical approval, preliminary data design and mapping of data sources. Also, as a validation of the available IOI-HA data, a web survey of VA audiologists was carried out to describe their habits in IOI-HA administration.

Contact person: Graham Naylor.

Research activities

Individualized hearing-aid acoustics based on reconstructing
the 3D geometry of the head and ear from 2D images
The overall aim of this PhD project is to establish a method for estimating individual hearing-aid acoustics, without the need for cumbersome acoustic measurements [47]. The envisaged pipeline is to capture 2D photos of the individual's head and ears, estimate a 3D model based on the 2D photos and a statistical shape model, use the 3D model for finite-element method acoustical simulations in order to achieve individual head related transfer functions (HRTF), and lastly to estimate the individual acoustical transforms required for the hearing-aid fitting.

The work in 2014 has focused on assessing the accuracy of HRTFs obtained from the intended modelling approach, in the light of the measurement accuracy that can be obtained in acoustical measurements with real humans. This was investigated in collaboration with the Acoustics Research Institute in Vienna, who made their HRTF measurement set-up and support available for this purpose. Thus, measurements were taken on four human subjects (including repeated measurements in one subject) and for a 3D-printed head model of one subject. Further, HRTFs were simulated by applying the finite element method to the 3D head model.

The head geometry that forms the basis for the 3D printed head model is seen in Figure 15. A computer-aided design software package was used to modify the initial model such that the printed model would fit on a torso simulator. Also, the ear-parts were separated from the remaining head to allow for printing in different materials. Figure 15 also shows the printed head. The ears were printed in a soft rubber-like material, to allow hearing aids to be fitted to the ears.

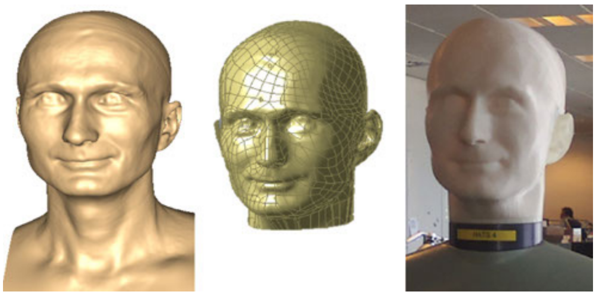


Figure 15: Left: acquired geometry, center: model used for printing. Right: printed head mounted on a torso simulator.

The combined data set of the Vienna HRTF measurements including 1550 source positions for both the real human and the printed-head model, and the corresponding HRTFs computed with the finite-element method is unique. Two journal papers with descriptions and analyses of the data set are in preparation and will be submitted for publication in early 2015.

A preliminary analysis suggests that the important interaural time-difference cue is very robustly captured by both types of measurements and the simulations. The more subtle and detailed monaural spectral cues, however, show more deviations – both among repeated measurements on the real human and among the two types of measurements and the simulations.

The project continues until March 2015.
PhD Student Stine Harder.
Contact person: Søren Laugesen.

Investigation into spatial release from masking and basic measures of auditory performance
Understanding spatial release from masking has been a long-standing research interest at Eriksholm. In this INSPIRE PhD secondment it was investigated how spatial release from masking may be predicted from basic measures of auditory and cognitive performance. To this end, speech recognition experiments using the DAT corpus were carried out with 20 hearing-impaired listeners in various backgrounds and in various configurations of simulated spatial separation.

The spatial separation was achieved over headphones by using only interaural time-difference cues. In addition, a range of basic auditory and cognitive measures were taken.

Preliminary analysis of the results indicates that spatial release from masking varies considerably among experimental conditions, but the individual differences appear to be difficult to predict.

PhD Student Gusztáv Lőcsei.
Contact person: Søren Laugesen.

Competing voices and temporal fine structure
Manipulations of monaural and binaural temporal fine structure As part of his PhD study, Andrew King completed a study on temporal fines structure and spatial unmasking in a loudspeaker study with a real-time master hearing aid (King et al, 2013)[1]. That 2013 study was a real acoustic environment follow-up to an earlier simulated study at Eriksholm that used headphones only (Andersen et al, 2011)[2]. The King study has now been submitted to Journal of the Acoustical Society of America (King et al, 2015)[3].

[1] King, A., Bramsløw, L., Vatti, M., Hafez, A., Pontoppidan, N.H., et al, 2013. The Benefit of Temporal Fine Structure in Spatial Release From Masking for Older Hearing-Impaired Listeners. In ISAAR 2013. Nyborg, Denmark: ISAAR.
[2] Andersen, M.R., Kristensen, M.S. Neher, T., Lunner, T., 2011. Side-Effects of Binaural Tone Vocoding on Recognising Target Speech Presented Against Spatially Separated Speech Maskers. In Proceedings of the International Symposium on Audiological and Auditory Research (ISAAR), Denmark. Nyborg, Denmark, pp. 103–110. 3 King, A., Pontoppidan, N.H., Bramsløw, L., Hietkamp, R., Vatti, M., et al, 2015. Old hearing-impaired listeners use temporal fine structure in spatial release from masking. J. Acoust. Soc. Am., submitted.

PhD Student Andrew King, University of Manchester.
Contact person: Lars Bramsløw.

Appendices

Publications

Papers in peer-reviewed journals

1. Preminger JE, **Laplante-Lévesque A**. (2014). *Perceptions of age and brain in relation to hearing help seeking and rehabilitation*. Ear and Hearing, 35, 19-29.

2. Jennings MB, Cheesman MF, **Laplante-Lévesque A**. (2014). *Psychometric properties of the Self-Efficacy for Situational Communication Management Questionnaire (SESMQ)*. Ear and Hearing, 35, 221-229.

3. **Laplante-Lévesque A**, Hickson L, Grenness C. (2014). *An Australian survey of audiologists' preferences for patient-centredness.* International Journal of Audiology, 53, S76-S82.

4. Grenness C, Hickson L, **Laplante-Lévesque A**, Davidson B. (2014). *Patient-centred care: A review for rehabilitative audiologists.* International Journal of Audiology, 52, 1-8.

5. Grenness C, Hickson L, **Laplante-Lévesque A**, Davidson B. (2014). *Patient-centred audiological rehabilitation: Perspectives of older adults who own hearing aids.* International Journal of Audiology, 53, S68-S75.

6. Grenness C, Hickson L, **Laplante-Lévesque A**, Meyer C, Davidson B. (2015). *The nature of communication throughout diagnosis and management planning in initial audiologic rehabilitation consultations.* Journal of the American Academy of Audiology, 26, 36-50.

7. Grenness C, Hickson L, **Laplante-Lévesque A**, Meyer C, Davidson B. (in press). *Communication patterns in audiologic rehabilitation history-taking: Audiologists, patients and their companions.* Ear and Hearing. 36, 191-204.

8. **Lunner T.** *About cognitive outcome measures at ecological signal-to-noise ratios and cognitive-driven hearing aid signal processing.* American Journal of Audiology. In press.

9. **Laplante-Lévesque A**, **Nielsen C, Jensen LD, Naylor G**. (2014). *Patterns of hearing aid usage predict hearing aid use amount (data-logged and self-reported) and over-report.* Journal of the American Academy of Audiology, 25, 187-198.

10. **Laplante-Lévesque A**, **Thorén ES**. *Readability of internet information on hearing: Systematic literature review.* American Journal of Audiology. Submitted.

11. Brännström, KJ, Öberg M, Ingo E, Månsson KM, Andersson G, **Lunner T, Laplante-Lévesque A**. *The development and initial evaluation of an internet-based support system for audiologists and first-time hearing aid clients.* International Journal of Audiology. Submitted.

12. Brännström, KJ, Öberg M, Ingo E, Månsson KM, Andersson G, **Lunner T, Laplante-Lévesque A**. *The process of developing an internet-based support system for audiologists and first-time hearing aid clients.* American Journal of Audiology. Submitted.

13. Wänström G, Öberg M, Rydberg E, **Lunner T, Laplante-Lévesque A**, Andersson G. *The psychological process from avoidance to acceptance in adults with acquired hearing impairment.* Hearing, Balance and Communication. 12,(1) 27-35.

14. Ellis R, Molander P, Rönnberg J, Lyxell B, Andersson G, **Lunner T**. *Predicting Speech-in-Noise Recognition from Performance on the Trail Making Test: Results from a Large-Scale Internet Study.* Ear and Hearing. Submitted.

15. Arehart K, Souza P, Kates J, **Lunner T**, Pedersen MS. *Relationship between distortion, hearing loss and working memory for digital noise reduction.* Journal of the Acoustical Society of America. Submitted.

16. **Lunner T**. *About cognitive outcome measures at ecological signal-to-noise ratios and cognitive-driven hearing aid signal processing.* American Journal of Audiology. In press.

17. Manchaiah V, Rönnberg J, Andersson G, **Lunner T.** *Stages of change profiles among adults experiencing hearing difficulties: A cross-sectional study.* PLos One. Submitted.

18. Manchaiah V, Rönnberg J, Andersson G, **Lunner T.** *Use of the 'patient journey' model in the internet-based pre-fitting counseling of a person with hearing disability: lessons from a failed clinical trial.* BMC Ear Nose Throat Disorder Apr 7;14(1):3

19. Manchaiah V, Danermark B, Rönnberg J, **Lunner T**. *Importance of "process evaluation" in audiological rehabilitation: examples from studies on hearing impairment.* Int J Otolaryngol. 2014:168684.

20. Manchaiah V, Molander P, Rönnberg J, Andersson G, **Lunner T.** *The acceptance of hearing disability among adults experiencing hearing difficulties: a cross-sectional study.* BMJ Open 4(1), e004066.

21. Mishra S, Stenfelt S, **Lunner T**, Rönnberg J, Rudner M. *Cognitive spare capacity in older adults with hearing loss.* Frontiers Aging Neuroscience. May 19;6:96.

22. Mishra S, Stenfelt S, **Lunner T**, Rönnberg J, Rudner M. *Good working memory capacity facilitates episodic long-term memory encoding of speech in stationary noise. Journal of Speech, Language, and Hearing Research.* Submitted.

23. Mishra S, Stenfelt S, **Lunner T,** Rönnberg J, Rudner M. *Older adults benefit more from enhanced listening conditions.* Frontiers in Psychology. Submitted.

24. Ng EHN, Classon E, Larsby B, Arlinger S, **Lunner T**, Rudner M, Rönnberg J. *Dynamic relation between working memory capacity and speech recognition in noise during the first six months of hearing aid use.* Trends in Hearing. 18: 1–10.

25. Ng EHN, Rudner M, **Lunner T**, Rönnberg J. *Noise reduction improves memory for target language speech in competing native but not foreign language speech. Early online 1-9.* Ear and Hearing. 36, 82-91.

26. Rudner M, **Lunner T**. *Cognitive Spare Capacity and Speech Communication: A Narrative Overview.* BioMed Research International Volume 2014, pp 10, Article ID 869726.

27. Rönnberg J, Rudner, M, **Lunner T**. *Editorial Material: Listening effort and fatigue: What exactly are we measuring? A British Society of Audiology Cognition in Hearing Special Interest Group white paper Comments from Dr. Jerker Ronnberg, Mary Rudner, Thomas Lunner.* International Journal of Audiology 53(7) 441-442.

28. Rönnberg N, Rudner M, **Lunner T**, Stenfelt, S. *Memory performance on the Auditory Inference Span Test is independent of background noise type for young adults with normal hearing at high speech intelligibility.* Frontiers in Psychology. December 2014. doi: 10.3389/fpsyg.2014.01490

29. Rönnberg N, Rudner M, **Lunner T,** Stenfelt S. *Adverse listening conditions affect short-term memory storage and processing of speech for older adults with hearing impairment.* Frontiers in Psychology. Submitted.

30. Rönnberg N, Rudner M, **Lunner T**, Stenfelt S. *Assessing listening effort by measuring short-term memory storage and processing of speech in noise.* Speech Language and Hearing. 17(3), pp.123-132.

31. Vlaescu G, Carlbring P, **Lunner T**, Andersson. *An e-platform for rehabilitation of persons with hearing problems.* American Journal of Audiology. Submitted.

32. **Naylor G**, Öberg M, Wänström G, **Lunner T.** *Exploring the Effects of the Narrative Embodied in the Hearing Aid Fitting Process on Treatment Outcome.* Ear and Hearing. In press.

33. Preminger JE, **Oxenbøll M**, Barnett MB, **Jensen LD**, **Laplante-Lévesque A**. (2015). *Perceptions of adults with hearing impairment regarding the promotion of trust in hearing healthcare services delivery.* International Journal of Audiology, 54, 20-28.

Appendices

34. **Petersen EB**, Wöstmann M, Obleser J, Stenfelt S, Lunner T. *Hearing loss impacts neural alpha oscillations under adverse listening conditions.* Frontiers in Psychology. In press.

35. **Petersen EB**, **Lunner T**, Vestergaard M, **Thorén ES**. *Normative Reading Span Data from 283 Hearing Aid Users and the Relationship to Performance in Speech-in-Noise Test.* International Journal of Audiology. Submitted.

36. King A, **Pontoppidan NH**, **Bramsløw L, Hietkamp R, Vatti M, Hafez A,** Hopkins K and Plack C. *Old hearing-impaired listeners use temporal fine structure in spatial release from masking.* Submitted to J. Acoust. Soc. Am.

37. Mathew AK, Purdy SC, Welch D, **Pontoppidan NH, Rønne FM**. *Electrophysiological and behavioural measures of complex acoustic cues.* Submitted to Clinical Neurophysiology.

38. **Thorén ES**, Öberg M, Wänström G, Andersson G, **Lunner T**. *A randomized controlled trial evaluating the effects of online rehabilitative intervention for adult hearing aid users.* International Journal of Audiology, 53 (7). pp.452-461

39. **Thorén ES**, Öberg M, Andersson G, **Lunner T**. (Submitted in December 2014). *Internet interventions for hearing loss.* American Journal of Audiology.

40. **Vatti M**, Santurette S, **Pontoppidan NH**, Dau T (2014). *Perception of a Sung Vowel as a Function of Frequency-Modulation Rate and Excursion in Normal-Hearing and Hearing-Impaired Listeners.* Journal of Speech, Language, and Hearing Research, vol. 57, pp. 1961–1971.

Other papers

41. **Laplante-Lévesque A**. *Applying the stages of change to audiologic rehabilitation.* Submitted to Hearing Journal in November 2014.

42. Preminger J, **Laplante-Lévesque A**. (2014). *How adults with hearing impairment perceive the role of aging and cognition in help-seeking and rehabilitation.* Audacity – A British Society of Audiology publication, Issue 3, April 2014, p. 31-32.

43. **Lunner T.** *Don't Forget the Brain: Hearing Loss and Hearing Aids.* Audiology Today, 26(4) p.36.

44. **Lunner T** & Ng EHN. *How cognition influences hearing aid use.* ENT News. Pp 36.

45. **Thorén ES**. (2014). *Online hearing help [Hörselhjälp på nätet].* Äldre i centrum, nr 3.

46. **Thorén ES**. (2014). *Rehabilitation via Internet [Rehabilitering via Internet].* Audionomen.

Papers published in conference proceedings

47. Huttunen T, Vanne A, **Harder S**, Paulsen RP, King S, Perry-Smith L, Kärkkäinen L. *Rapid generation of personalized HRTFs.* 55th International Conference on Spatial Audio 2014, Helsinki.

48. Rudner M, **Lunner T**. *Cognitive aspects of auditory plasticity across the lifespan.* 4th International Symposium on Audiological and Auditory Research, ISAAR. pp. 201-211

49. **Vatti M**, Santurette S, **Pontoppidan NH,** Dau T (2014). *Maximum acceptable vibrato excursion as a function of vibrato rate in musicians and non-musicians.* Proceedings of Meetings on Acoustics (POMA), Acoustical Society of America (ASA), vol. 20, 050002, pp. 1-7.

Conferences

Conference posters

50. **Bramsløw L, Vatti M, Hietkamp RK, Pontoppidan NH**: *Binaural speech recognition for normal-hearing and hearing- impaired listeners in a competing voice test.* Speech In Noise, January 2015, Copenhagen, Denmark.

Appendices

51. **Bramsløw L, Vatti M, Hietkamp RK, Pontoppidan NH**: *Design of a competing voices test.* International Hearing Aid Research Conference, IHCON, Lake Tahoe, California, USA, August 13-17.

52. **Jensen LD**, Preminger J, **Oxenbøll M,** Barnett M, **Laplante-Lévesque A**. *Creating and maintaining trust in hearing healthcare services.* Nordic Conference – from Family Intervention to Education in a New Era, Stockholm, Sweden, October 1-2.

53. **Jensen NS, Laugesen S, Rønne FM, Simonsen CS, Kijne JCB**. *Validation of the Spatial Fixed-SNR (SFS) test in anechoic and reverberant conditions.* Poster presentation, annual conference of the British Society of Audiology, Keele, UK, September 1-3.

54. Frederick M, Saunders G, Silverman S, **Laplante-Lévesque A, Jensen LD, Nielsen C, Oxenbøll M**. *Health behavior change in adults with hearing impairment.* American Auditory Society Meeting, Scottsdale, AZ, USA, March 6-8.

55. **Laplante-Lévesque A, Jensen LD, Oxenbøll M, Nielsen C**, Frederick M, Silverman S, Saunders G. *Health behavior change in adults with hearing impairment.* World Congress of Audiology, Brisbane, Australia, May 5-7.

56. **Laplante-Lévesque A, Jensen LD, Oxenbøll M, Nielsen C**, Frederick M, Silverman S, Saunders G. *Health behavior change in adults with hearing impairment.* Summer school on Pitch, music and associated pathologies, Lyon, France July 9-11.

57. **Laplante-Lévesque A**, Brännström J, **Lunner T**. *Stages of change in adults who failed an online hearing screening.* Internet & Audiology Meeting, Linköping, Sweden, October 3-4.

58. Ng EHN, Rudner M, **Lunner T**, & Rönnberg J. *Noise reduction improves memory for target speech heard in competing speech.* International Hearing Aid Research Conference, IHCON. Lake Tahoe, California, USA, August 13-17.

59. **Lunner T, Grube Sorgenfrei M, Vatti M, Hietkamp R**, Gusatovic D, & **Naylor G**. *Beyond speech intelligibility testing: A memory test for assessment of signal processing interventions in ecologically valid listening situations.* Poster presentation, International Hearing Aid Research Conference, IHCON. Lake Tahoe, California, USA, August 13-17.

60. **Lunner T, Grube Sorgenfrei M, Vatti M, Hietkamp R**, Gusatovic D, & **Naylor G**. *Beyond speech intelligibility testing: A memory test for assessment of signal processing interventions in ecologically valid listening situations.* 8th International Symposium on Objective Measures in Auditory Implants Toronto, Canada, October 15-18.

61. Barnett M, **Oxenbøll M, Jensen LD, Laplante-Lévesque A**, Preminger J. P*atient trust in hearing healthcare: Commercialism vs. patient-centered care.* American Academy of Audiology (AudiologyNow!). Orlando, FL, USA, March 26-29.

62. **Petersen EB**, Wöstmann M, Obleser J, Stenfelt S, **Lunner T**. *Compensated hearing loss predicts generation of auditory evoked potentials.* In: Poster presented at the Society for Neuroscience (SfN) 44th annual meeting, Washington DC, USA, November 15-19.

63. **Pontoppidan NH, Rønne FM**, Mathew AK, Purdy SC: *Transformation of lost segregation cues in hearing devices.* Poster at 8th International Symposium of Objective Measures in Auditory Implants, Toronto, Canada, October 15-18.

64. **Thorén ES**, Andersson G, Lunner T. *The use of research questionnaires with hearing impaired adults: Online vs. paper-and-pencil administration.* 1st International Symposium on Innovative Paediatric Hearing Science, Cernobbio, Italy, June 4

65. **Thorén ES**, Andersson G, **Lunner T**. *The use of research questionnaires with hearing impaired adults: Online vs. paper-and-pencil administration.* 1st International Meeting in Internet & Audiology, Linköping, Sweden, October 3-4.

Appendices

Conference presentations

66. Saunders G, Frederick M, Silverman SP, **Jensen LD, Laplante-Lévesque A**. *Health behavior change in adults with hearing impairment.* IHCON, Lake Tahoe, California, August 13-17.

67. **Jensen LD**. *Online surveys.* 1st International Meeting in Internet & Audiology, Linköping, Sweden, October 3-4.

68. **Laplante-Lévesque A**. *Client involvement and self-determination: A shared decision making model.* Inspiration til fremtidens rehabilitering af mennesker med hørenedsættelser (Inspiration to the future of rehabilitation of people with hearing loss) Conference, Copenhagen, Denmark, February 21.

69. **Laplante-Lévesque A**, Brännström KJ, Ingo E, Andersson G, **Lunner T**. *Stages of change in adults who have failed an online hearing screening.* American Auditory Society Meeting, Scottsdale, AZ, USA, March 6-8.

70. **Laplante-Lévesque A**. *Stages of change in adults with hearing impairment: Applications of the transtheoretical model.* Audiology and Deafness Oticon Seminar, University of Manchester, UK, April 3.

71. **Laplante-Lévesque A**, Hickson L, Grenness C. An *Australian survey of audiologists' preferences for patient-centredness.* World Congress of Audiology, Brisbane, Australia, May 5-7.

72. **Laplante-Lévesque A**, Velde T. *Trust, patient-centredness and shared decision making: What people with hearing impairment want.* World Congress of Audiology, Brisbane, Australia, May 5-7.

73. **Laplante-Lévesque A**, Brännström J, Öberg M, Ingo E, Andersson G, Lunner T. A*n online support system for audiologists and their first-time hearing aid clients.* World Congress of Audiology, Brisbane, Australia, May 5-7.

74. **Laplante-Lévesque A**, Brännström KJ, Ingo E, Andersson G, **Lunner T**. *Stages of change in adults who have failed an online hearing screening.* Hearing Across the Lifespan, Cernobbio, Italy, June 5-7.

75. **Laplante-Lévesque A**, Brännström KJ, Andersson G, Lunner T. *Quality and readability of Internet information on hearing.* 1st International Meeting in Internet & Audiology, Linköping, Sweden, October 3-4.

76. Weineland S, Andersson G, Carlbring P, Hesser H, Ingo E, **Lunner T**, Molander P, Nordqvist P, **Laplante-Lévesque A**. *Motivational Interviewing Via Internet (MIVI).* 1st International Meeting in Internet & Audiology, Linköping, Sweden, October 3-4.

77. Brännström J, Öberg M, Ingo E, Månsson KNT, Andersson G, **Lunner T, Laplante-Lévesque A**. *An internet-based support system for audiologists and their first-time hearing aid clients.* 1st International Meeting in Internet & Audiology, Linköping, Sweden, October 3-4.

78. **Laplante-Lévesque A**. *Shared decision making in audiology. Foreningen af Universitetsuddannede Audiologopæder (Danish Association of University-trained Audiologists and Speech Pathologists).* Copenhagen University, Denmark, October 8.

79. **Laplante-Lévesque A**, Andersson G, Brännström J, Hickson L, Ingo E, **Lunner T**, Worrall L. *Applying the stages of change model to audiologic rehabilitation.* Canadian Academy of Audiology Conference, Whistler, Canada, October 15-18.

80. **Laplante-Lévesque A**, Hickson L, Grenness C. *A survey of audiologists' preferences for patient-centredness.* Canadian Academy of Audiology Conference, Whistler, Canada, October 15-18.

81. **Laplante-Lévesque A**. *Shared decision making in audiology. Foreningen af Universitetsuddannede Audiologopæder (Danish Association of University-trained Audiologists and Speech Pathologists).* University of Southern Denmark, Denmark, November 5.

82. **Lunner T.** Ng EHN, Rudner M, Rönnberg J. *Beyond speech intelligibility testing. A memory test for assessment of signal processing interventions in ecologically valid listening situations.* Speech In Noise Conference (SPIN), Marseille, France, January 9-10.

83. **Lunner T**. *Kognitiva hörapprater.* Hard of Hearing Associacion (Temadag Kognition, Hörselskadades Riksförbund, HRF). Wallenbergsalen. Länsmusset, Linköping Sweden. March 20.

84. **Lunner T**. *Don't Forget the Brain: Hearing Loss and Hearing Aids.* Academy Research Conference (ARC), AudiologyNOW! Orange County Convention Center West Orlando, Florida, USA, March 26.

85. **Lunner T**. *Kognitiva Hörapparater och Internet rehabilitering, Översikt över två forskningsområden i samarbete mellan Eriksholm och Linköpings universitet.* Svensk Teknisk Audiologisk Förening (STAF). Hotell Tylösand, Halmstad, Sweden, March 12.

86. **Lunner T**. *Cognitive hearing aids and top-down/ bottom-up issues.* HEaring Across the Lifespan (HEAL). Cernobbio, Lake Como, Italy, June 5-7.

87. Bernstein JGW, Danielsson H, Hällgren M, Rönnberg J, **Lunner T**. *Spectrotemporal modulation sensitivity as a predictor of speech intelligibility in noise with hearing aids.* Oral presentation, International Hearing Aid Research Conference, IHCON. Lake Tahoe, California, USA, August 13-17.

88. **Lunner T**. *A Swedish tele-audiology research program from detection to intervention: experiences and future perspectives.* The Internet & Audiology. Linköping University, Linköping, Sweden, October 3-4.

89. **Lunner T**. *Kognitiva hörapparater. Oticon.* Audiologikursen 2014. Nordic C Hotel, Stockholm, Sweden, October 8.

90. **Lunner T.** *Kognitiva Hörappråter. Praktisk nytta av IHVs forskning – om funktionsnedsättning och funktionshinder.* Nordic Light Hotel, Stockholm, Sweden. October 20.

91. **Naylor G**. *Gatehouse Memorial Lecture 2014: Audiological rehabilitation is about unique human beings with real lives: trends in trends in research on candidature and auditory ecology.* International Hearing Aid Research Conference IHCON, Lake Tahoe, California, August 13-17.

92. **Petersen EB, Lunner T**. *Cognitive Hearing Aids? - Insights and Possibilities.* 12th international workshop in Mechanics of Hearing, Cape Sounio, Greece, May 23-29.

93. Mathew AK, Purdy SC, Welch D, **Pontoppidan NH, Rønne FM**. *Electrophysiological and behavioral measures of temporal fine structure processing.* In XXXII World Congress of Audiology, May 3-7.

94. **Pontoppidan NH**: *Ear EEG and cognitive measures in future hearing care.* 8th International Symposium on Objective Measures in Auditory Implants, Toronto, Canada, October 16-18.

95. **Thorén ES**, Wänström G, Öberg M, Andersson G, **Lunner T**. Professional online rehabilitation of hearing-aid users. HEAL 2014, Cernobbio, Italy, June 5-7.

96. **Thorén ES**, Wänström G, Öberg M, Andersson G, **Lunner T**. *Internet interventions.* 1st International Meeting in Internet & Audiology, Linköping, Sweden, October 3-4.

Conference participation

Speech In Noise Conference (SPIN), Marseille, France, January 9-10 was attended by Thomas Lunner.

Inspiration til fremtidens rehabilitering af mennesker med hørenedsættelser (Inspiration to the future of rehabilitation of people with hearing loss), Copenhagen, Denmark, February 21 was attended by Ariane Laplante-Lévesque.

American Auditory Society Meeting, Scottsdale, AZ, USA, March 6-8 was attended by Ariane Laplante-Lévesque.

Svensk Teknisk Audiologisk Förening (STAF), Hotell Tylösand, Halmstad, Sweden, March 12 was attended by Thomas Lunner.

Hard of Hearing Association (Temadag Kognition, Hörselskadades Riksförbund, HRF), Wallenbergsalen, Länsmusset, Linköping Sweden, March 20 was attended by Thomas Lunner.

Appendices

Academy Research Conference (ARC), AudiologyNOW!, Orange County Convention Center West Orlando, Florida, USA, March 26 was attended by Thomas Lunner.

World Congress of Audiology, Brisbane, Australia, May 5-7, was attended by Ariane Laplante-Lévesque.
International Symposium on Innovative Paediatric Hearing Science, Cernobbio, Italy, June 4 was attended by Ariane Laplante-Lévesque, Thomas Lunner, and Elisabet S Thorén.

Hearing Across the Lifespan, Cernobbio, Italy, June 5-7 was attended by Ariane Laplante-Lévesque, Thomas Lunner, and Elisabet S Thorén.

Summer school on Pitch, music and associated pathologies, Lyon, France, July 9-11, was attended by Ariane Laplante-Lévesque.

Workshop and Summer School on "Auditory Attention and Scene Analysis", Delmenhorst, Germany, July 21 - 23 was attended by Lars Bramsløw.

International Hearing Aid Research Conference (IHCON), Lake Tahoe, California, August 13-17, was attended by Graham Naylor and Niels Henrik Pontoppidan.

The annual conference of the British Society of Audiology (BSA), Keele, UK, September 1-3, was attended by Renskje Hietkamp and Niels Søgaard Jensen.

Annual meeting of the Danish Technical Society of Audiology, Vejle, Denmark, September 12-13 was attended by Filip Marchman Rønne.

Nordic Conference – from Family Intervention to Education in a New Era (NCFIE 2014), Stockholm, Sweden, October 1-2, was attended by Lisbeth Dons Jensen.

Internet & Audiology Meeting, Linköping, Sweden, October 3-4 was attended by Lisbeth Dons Jensen, Ariane Laplante-Lévesque, Thomas Lunner, and Elisabet S Thorén.

Audiologikursen Oticon 2014, Nordic C Hotel, Stockholm, Sweden, October 8 was attended by Thomas Lunner.

Canadian Academy of Audiology Conference, Whistler, Canada, October 15-18 was attended by Ariane Laplante-Lévesque.

8th International Symposium on Objective Measures in Auditory Implants, Toronto Canada, October 16-18 was attended by Niels Henrik Pontoppidan.

20th Annual Qualitative Health Research Pre-Conference Workshop, Victoria, Canada, October 20 was attended by Ariane Laplante-Lévesque.

Praktisk nytta av IHVs forskning – om funktionsnedsättning och funktionshinder. Nordic Light Hotel, Stockholm, Sweden. October 20 was attended by Thomas Lunner.

Academic relations

Peer reviews made

Lars Bramsløw reviewed three manuscripts for *Journal of the Audio Engineering Society (JAES),* one manuscript for the online journal Trends in Hearing, and one manuscript for the online journal PLOS ONE.

Niels Søgaard Jensen reviewed two manuscripts for the *International Journal of Audiology.*

Søren Laugesen reviewed and re-reviewed one manuscript for J*ournal of the American Academy of Audiology,* reviewed one and re-reviewed another manuscript for *Ear and Hearing*, and reviewed one manuscript for International *Journal of Audiology.*

Ariane Laplante-Lévesque reviewed four manuscripts for *Ear and Hearing*, three manuscripts for *Journal of the American Academy of Audiology,* one manuscript for *International Journal of Audiology,* one manuscript for *Gerontology,* one manuscript for *Rehabilitation Research and Practice*, and one research report for Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST).

Thomas Lunner reviewed two manuscripts for *Journal of the Acoustical Society of America*, three manuscripts for *Ear and Hearing*, two manuscripts for *American Journal of Audiology*, one manuscript for *International Journal of Otolaryngology* and one grant application for *Action on Hearing Loss.*

Appendices

Graham Naylor reviewed one manuscript for each of *Journal of the Acoustical Society of America, Journal of the Audio Engineering Society, Journal of the American Academy of Audiology, Ear & Hearing,* and *Computers in Biology and Medicine* and one grant proposal for *Action on Hearing Loss*.

Elisabet S Thorén reviewed two manuscripts for *International Journal of Audiology* and two manuscripts for *American Journal of Audiology.*

Supervision of students at Eriksholm Research Centre

S1. Thomas Lunner supervised an industrial PhD student at Linköping University (Elisabet S Thorén: I*nternet interventions for hearing loss,* supervisors from Linköping University Gerhard Andersson and Marie Öberg). PhD thesis was successfully defended on February 27 2014. Project supported by the Oticon Foundation.

S2. Thomas Lunner is supervising an industrial PhD student at Linköping University (Eline Borch Petersen: *Online cognitive workload estimation,* supervisor from Linköping University Stefan Stenfelt, Max Planck Institute Leipzig supervisor Jonas Obleser). Work continues in 2015. Project supported by the Oticon Foundation.

Supervision of students external to Eriksholm Research Centre

S3. Ariane Laplante-Lévesque co-supervised a PhD student at the University of Melbourne, Australia (Caitlin Grenness: *The patient-practitioner relationship: Older adults and their audiologists,* other co-supervisors Professors Louise Hickson, The University of Queensland and Bronwyn Davidson, The University of Melbourne). The work was finalised in 2014.

S4. Ariane Laplante-Lévesque is co-supervising a PhD student at Linköping University, Sweden (Elisabeth Ingo: *Internet-based hearing screening, treatment and motivational interviewing,* other co-supervisors from Linköping University, Professors Thomas Lunner and Gerhard Andersson). The work continues in 2015.

S5. Søren Laugesen supervises a PhD project at DTU Compute, Technical University of Denmark (Stine Harder: *Individualized directional microphone optimization in hearing aids based on reconstructing the 3D geometry of the head and ear from 2D images,* supervisor from Technical University of Denmark Rasmus Reinhold Paulsen).

S6. Søren Laugesen supervises a PhD project at Centre for Applied Hearing Research (CAHR), Technical University of Denmark (Jens Cubick: *Characterizing the auditory cues for the processing and perception of spatial sounds,* supervisors from Technical University of Denmark Torsten Dau and Sébastien Santurette).

S7. Søren Laugesen was secondment host for PhD student Gusztáv Lőcsei, Technical University of Denmark as part of the ITN-INSPIRE network. Academic supervisors: Ewen MacDonald, Technical University of Denmark and Stuart Rosen, University College London, United Kingdom.

S8. Thomas Lunner co-supervised a PhD student at the Swedish Institute of Disability Research, SIDR, Linköping University (Sushmit Mishra: *Sick and tired of listening – making listening inferences with a hearing impairment,* supervisor from Linköping University Mary Rudner). PhD thesis successfully defended March 21 2014.

S9. Thomas Lunner co-supervised a PhD student at the Swedish Institute of Disability Research, SIDR, Linköping University (Niklas Rönnberg: *Auditory Inference Span Test (AIST),* supervisor from Linköping University Stefan Stenfelt). Project supported by the Oticon Foundation. PhD thesis successfully defended September 19 2014.

S10. Thomas Lunner is co-supervising a PhD student at the Swedish Institute of Disability Research, SIDR, Linköping University (Peter Molander: *Hearing and cognitive screening over the internet,* supervisor from Linköping University Gerhard Andersson). Work continues in 2015.

S11. Thomas Lunner is co-supervising a PhD student at The Sahlgrenska Academy, Gothenburg University (Milijana Lundberg: *Clinical use of internet rehabilitation resources,* Gothenburg University supervisor Kim Kähäri, co-supervisor from Linköping University Gerhard Andersson). Work continues in 2015.

Appendices

S12. Thomas Lunner and Graham Naylor are co-supervising a PhD student at VU Medical Center, Amsterdam (Yang Wang: *Pupillary Light Reflex and Hearing Impairment,* VU Amsterdam Supervisor Sophia Kramer, Adriana Zekveld). EU Marie Curie FP7-PEOPLE-2013-ITN project LISTEN FP7-607373. Work continues in 2015.

S13. Thomas Lunner and Eline Borch Petersen co-supervised a MScEE exam project at Linköping University, Department of Electrical Engineering/Automatic Control. (Mattias Tiger: *Sparse linear modelling of speech from EEG,* LiU supervisor Thomas Schön). The work was successfully defended in May 2014.

S14. Graham Naylor and Thomas Lunner are co-supervising a PhD student at VU Medical Center, Amsterdam (Barbara Ohlenforst: *Pupillometry and listening effort,* VU Amsterdam Supervisor Sophia Kramer, Adriana Zekveld). EU Marie Curie FP7-PEOPLE-2013-ITN project LISTEN FP7- 607373. Work continues in 2015.

S15. Niels Henrik Pontoppidan co-supervised a PhD project at School of Psychological Sciences, Audiology & Deafness Research Group, The University of Manchester, United Kingdom (Andrew King: *The effect of age and hearing-impairment on interaural phase discrimination and spatial hearing,* Academic supervisors Christopher Plack and Kathryn Hopkins).

S16. Niels Henrik Pontoppidan was secondment host for PhD student Tom Barker, Tampere University of Technology as part of the ITN-INSPIRE network. Academic supervisors: Tuomas Virtanen, Tampere University of Technology and Hugo van Hamme, KU Leuven, Belgium.

S17. Elisabet Thorén supervised a Master thesis at Dept. of Logopedics, Phonatric and Audiology, Lund University, Sweden (Johanna Fred, Heike von Lochow and Henrietta Nilsson: *Correlation between benefits of bilateral hearing aid fitting and cognitive performance,* other co-supervisor Dr Marie Öberg).

S18. Elisabet S Thorén supervised a BSc-thesis at Dept. of Logopedics, Phonatrics and Audiology, Lund University, Sweden (Sonny Aldenklint & Stephanie Meier; *En jämförelse mellan två interventionsmetoder för den hörselproblematik som neurofibromatos typ II genererar - A literature study.)*

External examining

Lars Bramsløw was external examiner for the M.Sc.E project of Barbara Ohlenforst *Exploring the relationship between working memory, compressor speed and background noise characteristics* (Supervisor Ewen MacDonald and Northwestern supervisor: Pamela Souza) and the MSc project of Wiebke Lamping: "The role of frequency selectivity and harmonic resolvability for pitch discrimination", (Supervisors: Sebastién Santurette and Ewen MacDonald) both at Technical University of Denmark.

Niels Søgaard Jensen was the external examiner of the BSc project of Marc Dose *(Validation and improvement of a procedure for headphone calibration and equalization),* at the oral examination of 11 students in the course Technical Audiology, at the oral examination of 17 students in the course Auditory Signal Processing and Perception, and at the oral examination of 15 students in the course Acoustic Communication. All at Centre for Applied Hearing Research, Dept. of Electrical Engineering, Technical University of Denmark.

Søren Laugesen was the external examiner of the MSc project of Marc Rasmussen *(Behavioural measures and neural modelling of musical interval perception)* and the MSc project of Axel Ahrens *(Spectral weighting and combination of binaural cues across frequency bands)* at Centre for Applied Hearing Research (CAHR), and the BSc project of Peter Gormsen at Acoustic Technology, Dept. of Electrical Engineering, Technical University of Denmark.

Søren Laugesen was the external examiner at the PhD viva voce of Alan W. Boyd *(Experimental investigations of auditory externalization and the application of head-movement information to hearing-aid signal processing,* (University of Strathclyde supervisor John Soraghan, Institue of Hearing Research supervisor William Whitmer) at University of Strathclyde, Scotland.

Niels Henrik Pontoppidan was external examiner for the B. Sc.E. project of Anna Josefine Sørensen's bachelor project *Perception of gaps and overlaps in conversational turn-taking* (Ewen MacDonald, GnResound supervisor Adam Weiser) at Technical University of Denmark.

Teaching

Jensen LD, Nielsen C. *Understanding hearing aid use.* Teaching course at Lund University, September 30.

Laplante-Lévesque A. *Audiology* in Canada. Teaching course at Lund University, September 29.

Laplante-Lévesque A. *Patient involvement in audiological rehabilitation.* Teaching course at Lund University, September 30 – October 9.

Lunner T. *Cognitive Hearing Aids?* Presentation made at Aalborg University (AAU) March 13, 2014.

Lunner T. *Cognitive Hearing Aids?* Presentation made at the Boston University, March 24, 2014.

Pontoppidan NH, *Hearing Scientist in Hearing Aid Industry,* ITN-INSPIRE Winter School, Copenhagen, February, 2014.

Thorén ES. *Rehabilitation via internet.* Teaching course at Lund University, October 6.

Other activities

Ariane Laplante-Lévesque, Thomas Lunner and Elisabet S Thorén visited the Department of Logopedics, Phoniatrics and Audiology, Lund University, Sweden several times during the year.

Thomas Lunner visited the research group around Sophia Kramer at VU Medical Center, Amsterdam, January 22, April 10, and October 15.

Eline Borch Petersen spent a month in Leipzig together with the auditory cognition group from February 9 to March 3.

Ariane Laplante-Lévesque hosted Jill Preminger, Associate Professor at the University of Louisville, on February 19.

Jean Pierre Gagné from University of Montreal visited Eriksholm on February 25.

Thomas Lunner visited the auditory cognition group led by Jonas Obleser at MaxPlanck Institute, Leipzig 3-4 March.

Ariane Laplante-Lévesque hosted Jonas Brännström, Associate Professor at Lund University, on March 28.

Graham Naylor visited National Center for Rehabilitative Auditory Research (NCRAR), Portland, Oregon in April-May and October-November.

Gerhard Andersson, Peter Molander and Elisabeth Ingo, Linköping University, and Peter Nordqvist, Hörselbron, visited Eriksholm on April 1st.

Elisabet S Thorén hosted Milijana Lundberg Malmberg, PhD student at University of Gothenburg, on April 2-3, June 25 and September 1st.

Ariane Laplante-Lévesque visited the Audiology and Deafness Research Group, School of Psychological Sciences, University of Manchester, United Kingdom on April 3.

Ariane Laplante-Lévesque visited the Audiology Department, Withington Community Hospital, United Kingdom on April 4.

Søren Laugesen and Stine Harder visited Piotr Majdak and colleagues at Acoustics Reseach Institute, Vienna, Austria, April 8-10, to work on HRTF measurements.

Ariane Laplante-Lévesque visited the Division of Audiology, School of Health and Rehabilitation Sciences, The University of Queensland in Brisbane, Australia on April 29 – May 2.

Lisbeth Dons Jensen, Ariane Laplante-Lévesque and Claus Nielsen hosted Gabrielle Saunders, Associate Director and Investigator, National Center for Rehabilitative Auditory Research (NCRAR) on June 16-20.

Fabrice Bardy, post doc at NAL, visited Eriksholm on June 16. Ariane Laplante-Lévesque visited the Institut des Sciences Cognitives, Lyon, France on July 8.

Ariane Laplante-Lévesque hosted Justine Lévesque, PhD student at the Université de Montréal, on August 7.

Niels Søgaard Jensen visited MRC Institute of Hearing Research, Glasgow, UK, on September 4.

Appendices

Ariane Laplante-Lévesque, Claus Nielsen, Thomas Lunner, Elisabet Sundewall Thorén, Lisbeth Dons Jensen and Lise Miller Bertram visited Forum Auditum, Croatia on September 8-12.

Niels Henrik Pontoppidan visited Andrew King at University of Manchester in October.

Ariane Laplante-Lévesque, Thomas Lunner and Elisabet Sundewall Thorén were part of the organising committee of the First International Internet & Audiology Meeting, October 3-4.

Ariane Laplante-Lévesque visited the National Center for Rehabilitative Auditory Research (NCRAR) on October 13.

Ariane Laplante-Lévesque and Thomas Lunner hosted Gerhard Andersson, Professor at Linköping University, Elisabeth Ingo, PhD Student at Linköping University, and Peter Nordqvist, Managing Director, Hearing Bridge Research Institute, on November 11.

Thomas Lunner visited Andreas Büchner and Marieke Finke, Deutsches Hörzentrum der Medizinischen Hochschule Hannover on November 19.

Golbarg Mehreai, Boston University, US visited Niels Henrik Pontoppidan in December.

Thomas Lunner visited Interacoustics A/S, Assens on December 2.

Graham Naylor participated as Oticon's representative in the Hearing Industry Research Consortium.

Storgaard D. Treatability: Sociomaterial configurations of diabetes and hearing loss. PhD thesis submitted to University of Southern Denmark.

Other extramural matters

Applications to research committees

An addendum to the protocol approved in 2011 was submitted to the Research Ethics Committees of the Capital Region of Denmark. The addendum adds new research methods to the protocol, which provides ethical clearance for the ongoing research projects at Eriksholm.

Awards and appointments

The paper "**Laplante-Lévesque A**, Hickson H, Worrall L (2013). *Stages of change in adults with acquired hearing impairment seeking help for the first time: Application of the transtheoretical model in audiologic rehabilitation.* Ear and Hearing, 34, 447-457." received the 2013 Ear and Hearing Editor's Award. The Award was presented at the 2014 American Auditory Society Meeting, Scottsdale, AZ, USA, March 6-8.

Ariane Laplante-Lévesque received funding from the French Embassy in Sweden through the 2014 FRÖ program. This provided financial support for a research stay in France.

Ariane Laplante-Lévesque received funding from Stiftelsen Tysta Skolan. This provided financial support for conference attendance.

Ariane Laplante-Lévesque was appointed as "docent" (Swedish equivalent to Associate Professor) in November 2014.

Elisabet S Thorén defended her PhD dissertation, *Internet intervention for hearing loss - examining rehabilitation, self-report Measures and Internet use for hearing aid users,* and fathered thus doctorate in medical science in February 2014.

Graham Naylor was appointed Distinguished Scholar in Residence at the National Center for Rehabilitative Auditory Research, Portland, Oregon.