2015 Annual Report

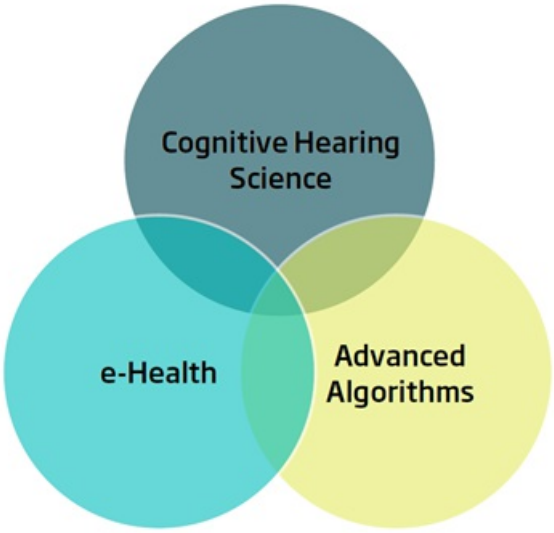
Director's report

The mission of the Eriksholm Research Centre

Eriksholm was established almost four decades ago. The five people who started at this time were given the task of investigating the impact of hearing aids on the users. Today, we have a significantly broader mission: We aim at making audiological discoveries with the potential to provide significantly enhanced end-user benefits in future hearing care.

Eriksholm's three strategic research areas

This ambition involves a variety of equally important research directions and thus, we have organized our work under three strategic research areas. Inspired by Megatrends formed by big streams of global research with impact on the future of hearing care, we have named them Advanced Algorithms, Cognitive Hearing Science, and eHealth. These Megatrends are evolving, regardless whether or how we contribute, so the challenge for us is to identify the right topics, bring the experts together and create scientific achievements to make new, groundbreaking innovations.



For more information

Bo Westergård

Head of Communications & Clinical Audiology

CV

mail@eriksholm.com

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Through 2015, Eriksholm has developed and expanded in each of these three strategic research areas. Within Cognitive Hearing Science an increasing number of scientists are in their right element in our new building, fully equipped with state of the art EEG and pupillomety equipment. The growing eHealth team has engaged in new, promising collaborations both in Denmark and internationally. Together with the Advanced Algorithms team, they have dedicated an increased amount of research resources to projects applicable for cochlear implants and bone anchored hearing solutions.

Every year we strengthen and expand our valuable network of collaboration partners internationally, and at all levels. As an example, in 2015 we had the highest number of both Post-docs, PhD students and Master students working at Eriksholm. They all bring enthusiasm, engagement, and refreshing inspiration to Eriksholm.

Advanced Algorithms

Why do we call this research Megatrend "advanced algorithms", aren't all algorithms advanced? Well, in digital signal processing we see big improvements in the way we can optimize the processing of sound, to optimally compensate for the individual hearing loss.
However, only a small portion of the algorithms developed in labs make their way into the hearing instruments. So far, the memory space and the available computing power of the digital signal processors have been the limiting elements.

For the hearing impaired the proverbial "cocktail party" situation is the worst scenario, when many people are talking at the same time and the acoustic scene is additionally "polluted" by other sounds like the rattling of dishes and cutlery, high music etc.

Here our research is seeking novel solutions by separating the individual voices from the babble of multiple talkers. An exercise which is easy routine for a person with normal hearing, but very challenging for a person with hearing impairment.

Algorithms doing voice separation have been known for quite a while, now they are quickly improving their performance. Additionally, the silicon engines of our future hearing instruments will be powerful enough to implement them. Particularly technologies like Deep Neural Network (DNN) open up exciting new possibilities. Many smartphone users already use these DNNs, e.g. when they use apps which can find persons or items in their picture gallery.

Follow this link to read more about Advanced Algorithms

Cognitive Hearing Science (CHS)

Here our focus through 2015 and into the near future is "Hearing & Cognition". We recently started the big European Horizon 2020 project "Cognitive Control of a Hearing Aid" (COCOHA). The project immediately won strong, international attention. Members of the CHS team have been invited speakers at numerous international conferences, not least at the prestigious Telluride Workshop in July 2015, where the topic was "Neuromorphic Cognition Engineering".

It is amazing to feel what "neuro-feedback" means for the Human Machine Interface. The CHS team demonstrates this with a "Restaurant Problem Solver": a physical set-up where a number of people around a table are represented each by one loudspeaker. When you join the table with an Ear-EEG sensor in your ear, you just need to look at the loudspeaker you want to listen to and it is amplified, whilst the other ones are attenuated. Easy to imagine this application in real life, where the Ear-EEG can be used to steer beam-forming microphones or to pick and choose button microphone attached to several speakers.

The reactions from hearing aid users trying this Restaurant Problem Solver have been ranging from "*when can I have this?*" to "*it is so intuitive and easy, you really feel in control*".

Follow this link to read more about Cognitive Hearing Science

eHealth

Health care systems around the world - private and public alike - are under heavy pressure, both time wise and financially. Customers demand better solutions, more services, and in some areas, e.g. hospitals doing cochlear implant surgery, the burden of aftercare is seen to become the limiting element for the treatment of new patients.

The promises of eHealth are big and driven by increasing functionality and connectivity of devices as well as increasing performance of software systems. Needless to mention the achievements of data mining technologies or machine learning.

However eHealth is not only about cool technologies, but also about health economics. eHealth solutions in audiology will only succeed if and when they are economically attractive both for the end users and the hearing care providers.

Eriksholm's research within eHealth is focusing on the complete patient journey starting from the first steps of a patient who is realizing that he/she needs to do something about the daily hearing challenges, over the clinical phases to post clinical treatment and rehabilitation.

All these topics and more were part of the Second International Conference on Internet and Audiology which was held at Eriksholm Research Centre in September 2015. More than 15 peer reviewed publications and consensus papers will become the rich harvest of this event.

Follow this link to read more about eHealth

The future…

What is the prospect of the future? We live in a time of rapid development which will create big benefits for hearing aid users and open up new chances and opportunities for the hearing aid

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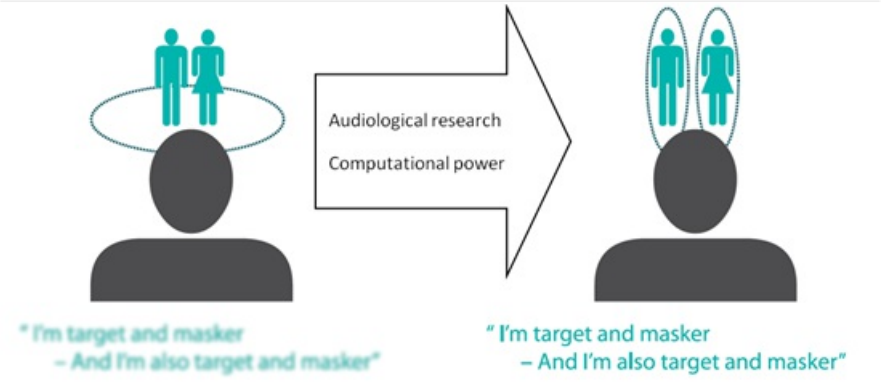
industry. This motivates all our activities here at Eriksholm Research Centre and, as we use to say: In Audiology, the best is yet to come!

Advanced Algorithms

The members of our strategic research area Advanced Algorithms, headed by **Niels Henrik Pontoppidan**, are dedicated to solving problems that people with hearing impairment experience in their daily life. They focus on making new discoveries, which can be of significant benefit to people with hearing loss, when combined withsemi-conductor technologies. Like Eriksholm in general, also the Advanced Algorithms team is experiencing an increase in international collaboration.

New listening tests

Listening tests are of immense importance in order to clarify, quantify and document e.g. a hypothesis on a problem. This is how most of our studies begin; is there a problem or not? We need to perform tests to determine the nature of the problem we wish to solve, or to test if the advantages we hope to create are at all measurable. And because we keep breaking new grounds, sometimes available tests are not adequate.
Thus, developing new means of measuring is an important part of the work at Eriksholm. In 2015, the Advanced Algorithms team developed a test to be able to identify and quantify the size of the problem which people with hearing loss experience when exposed to competing voices. The test enabled us to document this. For more information, **please go to this website**.



Separation of known 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, e.g. when watching television with a spouse, attending family dinners, while shopping, and of course in the proverbial cocktail party situation.

In our attempts to solve this problem, we have developed an algorithm that can recognise known voices and separate them in situations where people with hearing loss are not able to distinguish them today. The algorithm has been tested using desktop computer prototypes and it works so well that the test subjects perceives the voices as coming from different directions even though this is not the case.

The test demonstrated that we are now able to give the hearing aid user the perception that more than one voice is coming through the hearing aid. This adds significantly to the users level of comfort since less energy is needed to separate voices.

Surprisingly, the algorithm adds no benefit to speech perception. Investigating this further will be one of our next challenges.

Like many of the other problems we occupy ourselves with in our research work, the challenge of separating competing voices is equally relevant to people with age related hearing loss as well as people with cochlear implants. Thus, we dedicate research resources to make our research applicable for cochlear implant users as well as hearing aid users.

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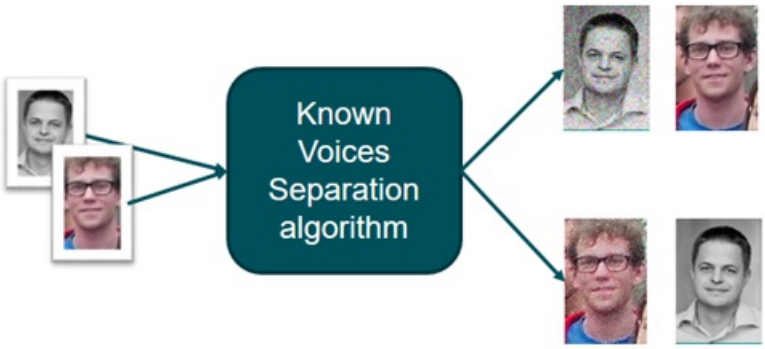
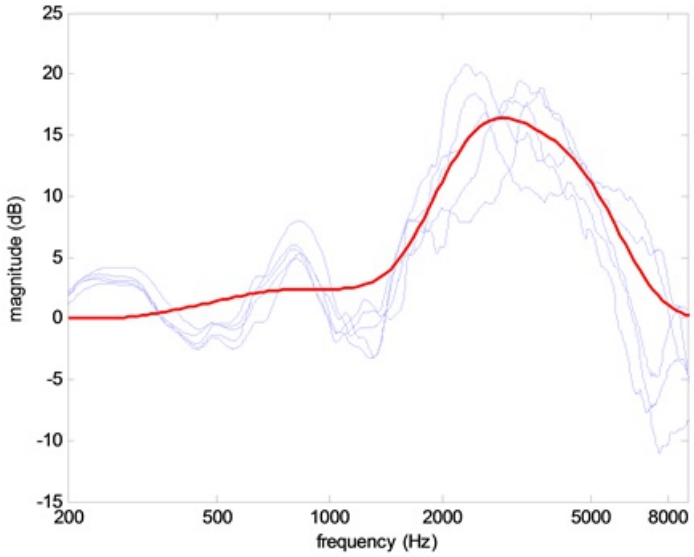


End-user benefits from individualized acoustical transforms in hearing aids

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 standardized, acoustical transforms.
The main purpose of this project, conducted in 2015, was to investigate whether using individualized acoustical transforms, as compared to using standardized acoustical transforms, has the potential to provide significant end-user benefits.
Our results indicate that yes: Normal hearing listeners (in this test representing new hearing aid users) do prefer the sound quality of a hearing aid programmed according to their own acoustical transforms.



If you wish to read on, follow this link to **the Advanced Algorithm section** of this website.

Cognitive Hearing Science

Imagine that one day, a hearing aid can read your mind and help you listen to what you really wish to hear. And imagine, that the very same hearing aid monitors your physiological wellbeing around the clock. We are still in the early days of personalized hearing solutions and cognitive research is an important way forward. This strategic research area was formerly known as Brain Computer Interface.

After years of research within this field, our huge interest in the cognitive aspects of audiology has rapidly expanded to also cover exciting areas like pupillometry, SWIRL and cognitive topics in general. In short you can say that our cognitive research activities have outgrown their rather limiting title and we needed to find a new and broader one. The new name is Cognitive Hearing Science.

Eriksholm's strategic research area, Cognitive Hearing Science, is headed by **Thomas Lunner**.

Learn more about Cognitive Hearing Science on **the Eriksholm webpage**.

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Two new PhD students joined Cognitive Hearing Science in 2015

Barbara Ohlenforst and Yang Wang are currently spending 1½ years at Eriksholm as part of their PhD projects under an EU Marie Curie grant given to Eriksholm in collaboration with VUMC, Amsterdam. The group at VUMC Amsterdam, led by Professor Sophia Kramer, is the leading institute within our field regarding listening effort and pupillometry.

Both PhD projects involve pupillometry, measuring the effects of cognitive effort on the pupils. Barbara is investigating the effects of listening effort while Yang is investigating if continuous cognitive strain is measurable on the pupils.

You can read more about Barbara's and Yang's projects here.

Cognitive control of a hearing aid

The vision of being able to cognitively control a hearing aid has been on the Eriksholm agenda for many years. Thus, Eriksholm was a driving force when defining the COCOHA (Cognitive Control of a Hearing aid) project in collaboration with École Normale Supérieure in Paris, UCL in London, UZH in Zürich and DTU in Copenhagen. The project, which has received funding from the European Union's Horizon 2020 research and innovation programme, has Thomas Lunner as Principal Investigator at Eriksholm.

Follow the link to learn more about COCOHA

Telluride – a playground for scientists

A great acknowledgement in 2015 was that Post-doc Carina Graversen was invited to participate in a Telluride conference in July. The participants are picked out among promising researchers within specific fields of research and they are invited to spend three weeks working together and sharing knowledge. One of the themes this year was influenced by Eriksholm's contribution to COCOHA, Ear-EEG, and Carina gained a lot of experience working for three weeks in this unique set-up. Besides working and networking, the participants in the Telluride conferences also enjoy visits from prominent researchers who come to present their work.

Pupillometry – a new research area at Eriksholm

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Pupillometry is a very interesting means of outcome measure for evaluating e.g. listening effort from hearing aid signal processing. Scientists at VUMC in Amsterdam have documented that the pupil size increases with listening effort. The effect is documented for both people with normal hearing and people with hearing loss. However, pupillometry has not yet been used for evaluating hearing aids.

One year ago, we established a pupillometry lab at Eriksholm and, as a first step, we have evaluated the method in Danish and found the same, significant results as VUMC.

Follow this link to read more about the test.

Fifth Eriksholm Workshop: Hearing Impairment and Cognitive Energy

The Oticon Foundation has established the Eriksholm Workshop series for gathering small groups of experts in audiology and hearing science to have focused discussions and exchange of information about an important area of study for the purpose of describing the topic, suggesting areas for further study, and, if appropriate, developing a consensus statement.

This fifth Eriksholm Workshop took place on June 3-5th, 2015, at Eriksholm Research Centre in Snekkersten, Denmark. 16 experts participated in the workshop and it was convened by Sophia Kramer from Department of Otolaryngology, Head and Neck Surgery, VU University Medical Center, Amsterdam, Netherlands, and Kathy Pichora-Fuller from the Department of Psychology at the University of Toronto in Mississauga, Ontario, Canada.

The outcome of the fifth Eriksholm Workshop is 17 articles to be published in a special edition of Ear and Hearing in 2016. The consensus paper introduces a new framework for understanding listening effort.

Follow this link to read more about the Eriksholm Workshops.

If you wish to read on, follow this link to **the Cognitive Hearing Science section** of this website.

eHealth

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Our strategic research area eHealth is headed by **Ariane Laplante-Lévesque**. eHealth helps the flow of information either within or around healthcare. Our vision is that one day, the primary health services for people with hearing impairment will be eHealth supported. All of our eHealth applications take the needs of the patient, the family, and the hearing care professional into consideration. This helps secure adherence with the hearing treatment. Learn more about eHealth on **the Eriksholm webpage**.

New colleague in eHealth

Annette Cleveland Nielsen joined the Eriksholm research team in June 2015. Annette holds a PhD in Veterinary Epidemiology and she brings solid experience in using health data to inform best practices. One of Annette's primary tasks is to move Eriksholm towards using Big Data within hearing health care.

Hearing health behavior change in adults with hearing impairment

In 2013, Eriksholm designed a two-phase study together with Gabrielle Saunders, PhD, and her colleagues at the **National Center for Rehabilitative Auditory Research**, Portland, Oregon, USA. The overall purpose of phase 1 was to get a better understanding of people's motivation for seeking hearing help and acquiring hearing aids. The results of phase 1 were used to develop an intervention to promote help seeking. In phase 2, this this intervention is being evaluated with a group of Veterans.
During 2015, phase 1 as well as the recruitment for phase 2 were completed.

Online Audiological Rehabilitation

Improving hearing aid outcomes through online rehabilitation has been an area of immense interest to us for years. In continuation of her PhD thesis, Internet Interventions for Hearing Loss, Elisabet Sundewal Thorén is now leading a project with the aim of developing a new, highly interactive online audiological rehabilitation program for hearing aid users. The multidisciplinary project team is working in close collaboration with hearing aid users to optimize the outcome of the program. The program aims at improving the hearing aid users' potential of becoming more satisfied with their situation as hearing aid users.
In addition to this, Elisabet is leading a publication of guidelines for developing internet interventions together with an international group of scientists and practitioners.

Follow **this link** to read more about the project.

eHealth solutions for cochlear implants

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During 2015, an Eriksholm initiated project of identifying eHealth solutions for cochlear implants was carried out in collaboration with Caitlin Grenness, PhD, Elisabeth Ingo, MSc, and Søren Kamaric Riis (Oticon Medical). The project was two-fold and included a systematic literature review and individual interviews with 11 clinicians to identify needs when it comes to eHealth solutions. The study revealed a preference for self-assessment solutions, e.g. smartphone apps.

Second International Meeting on Internet and Audiology

A new series of conferences has grown out of Eriksholm's wish to create a platform for an international exchange of knowledge in the rapidly developing field of eHealth. The First International Meeting in Internet and Audiology took place in Linköping on October 3-4, 2014. The scope was for the participants to gain insight into the work of leading eHealth scientists and for the Eriksholm researchers to present their work and concepts for future projects.
The international echo was strong and positive, and the participating scientists have decided to make the workshop a yearly event. The Second International Meeting on Internet and Audiology was held at Eriksholm Research Centre on September 24-25, 2015, this year with the participation of 70 experts and specialists from all over the world.

After the first meeting in 2014, Eriksholm co-edited a research forum of 17 peer-reviewed papers, summarizing the meeting. These papers were published in a **special edition of the American Journal of Audiology**, and a similar publication is under preparation after this year's meeting.

If you wish to read on, follow this link to **the eHealth section** of this website.

2015 in numbers

Follow each link to find out more.

22 papers published in peer reviewed journals
4 other papers
3 papers published in conference proceedings
26 conference posters
38 conference presentations
Participation in 35 conferences
31 articles reviewed for peer reviewed journals
Supervision of 10 students at Eriksholm Research Centre
Supervision of 17 students external to Eriksholm Research Centre
15 Examinings

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