

Eriksholm Annual Report 2016

2016 Annual Report

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2016 in numbers

Director's report

In 2017, Eriksholm Research Centre can celebrate 40 exciting years within audiological research and innovation.

40 years ago, hearing aids were analogue devices. The proverbial "beige banana" behind the ear, which amplified sound in a quality, which today's generation of smartphone addicts would consider as rather mediocre.

Modern digital hearing devices contain several signal processor cores with a computing power, which 40 years ago would have required a super-computer the size of a tennis court.

Today, hearing devices fulfill complex requirements far beyond simple amplification. They have hundreds of features and a highly automatic performance. Comparing today's hearing devices with those 40 years ago is almost like comparing techy, self-driving cars to a veteran car.

Looking back it seems as if technology and science are constantly accelerating. Moore's law has proven to hold its promise of doubling the power of a computer chip every 2 years. Today physicists tell us that they have sufficient ideas and concepts to continue driving along this learning curve for the next 20 years. At least. Imagine what this means for future hearing devices.

Radio technology has evolved, so hearing aids are now wireless devices, becoming part of the "internet of things". Connectivity to the smartphone has become a standard feature.

Software technology is almost exploding, and after more than 50 years in research labs, Artificial Intelligence (AI) now made it into the headlines of the **New York Magazine**. The article talks about the progress of natural language translation to a point, where it now becomes difficult to distinguish between a translation made by a computer and a professional translator. Similarly voice recognition and voice synthesis based on Deep Neural Networks (DNN) are quickly approaching human performance levels.

Again, imagine what this means for future hearing devices.

Here at Eriksholm, we are also deeply engaged in these research fields, which have the potential to revolutionize the capabilities of future hearing devices. Imagine what it means for the

For more information



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solution of the proverbial Cocktail Party effect, when DNN enable separation of the different talkers in a babble of voices. It will be possible to establish “super hearing”, where the user of a hearing device will be able to better understand the spoken words than normal hearing people. In parallel to all this, research into cognition and the functioning of the human brain is progressing fast. In our research labs we are already exploring how future generations of hearing devices can contain multiple sensors, which continuously analyse the brain signals, e.g. via EEG, for optimizing the listening experience of the user.

Future eHealth will enable us to support the user anytime, anywhere with personalized services, implementing the often quoted “personalized medicine” into hearing health care. The latest research in Cognitive Hearing Science aims at offering far better rehabilitation for the hearing impaired. Today we know that the plasticity of the human brain is much bigger than we dared to hope just 10 years ago.

Imagine how this will enable future eHealth to improve the user experience.

Our list of exciting research projects have the promise to improve future hearing healthcare to a point which many might consider science fiction today, just as one would have considered it science fiction 40 years ago to put a supercomputer into the ear.

This is only possible thanks to the fruitful collaboration with our academic partners around the world and to our international team of multidisciplinary researchers here at Eriksholm. At our 2016 Christmas celebration, we counted 12 different nationalities in our team. A remarkable achievement, particularly in these times where some talk about a new post-factual age, where science becomes “unimportant” and new walls are demanded.

Thank you all! We have a strong legacy as the basis for the next 40 years of scientific research.

Advanced Algorithms

Eriksholm’s strategic research area, Advanced Algorithms, is headed by **Niels Henrik Pontoppidan**.

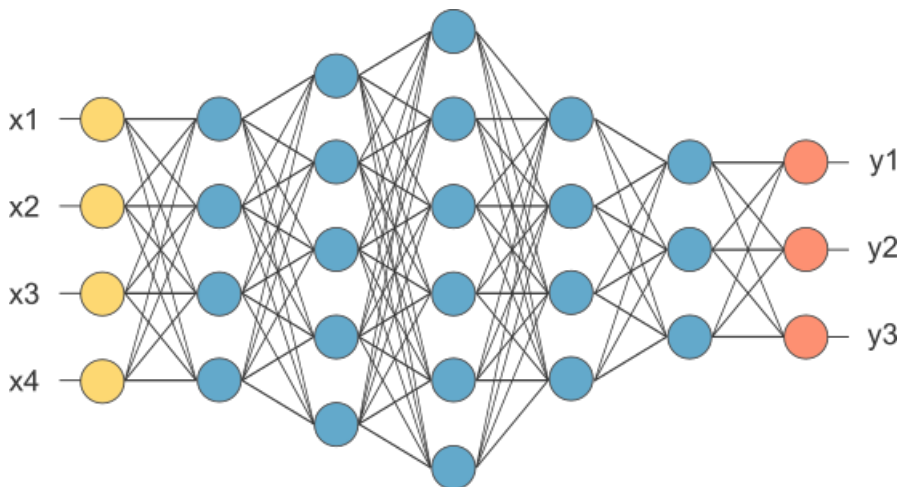
Learn more about **Advanced Algorithms** on the Eriksholm webpage.

In review 2016 proved to be another exciting year for the Advanced Algorithms research group. Tools change as hearing devices connect to internet services and increased computer power approaches hearing aids at fast pace. While the tools change, the task remains the same; expand the understanding of hearing loss to develop new, useful benefits and services. Together with our research partners, we have been working with new diagnostic methods, extending our understanding of how people with hearing loss use hearing device technology, and working to improve hearing technology.



Deep Neural Networks

A few months after coining the Cocktail Party term, Colin Cherry published how hearing devices could present multiple streams to people with hearing loss using artificial spatial cues. These ideas have not been implemented yet as they require advanced speech separation algorithms. We collaborate with Tampere University of Technology on separating competing voices with Deep Neural Networks (DNN) because the availability of neural computations is approaching the field of hearing devices. Our ambitions and hopes get higher when we see smartphones process live video using DNN available through Caffe2Go from Applied Machine Learning at Facebook.

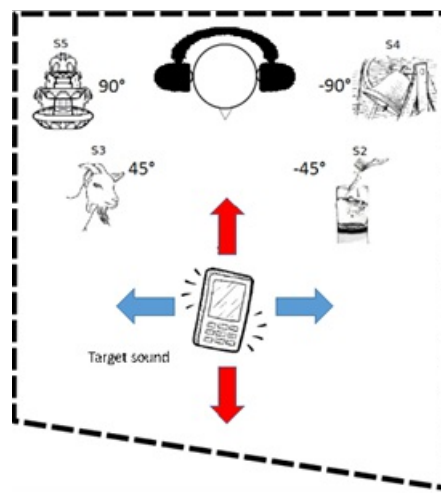


Schematic illustration of a Deep Neural Network (DNN)

Spatial awareness

Trying to understand hearing loss deeper also

means that tests and diagnostic methods continue to play an important part in our research. In 2016, we launched a collaboration with our colleagues at University of Salamanca with the aim to diagnose and further explain variation in hearing outcomes, which the audiogram does not explain. With University of Oldenburg, we continued our investigation of spatial awareness, to expand the understanding of how people with hearing loss perceive moving objects. When we initiate such research, the aim is to verify if problems exist, and if so, to develop a tool for benchmarking new algorithms.



The Music and Cochlear Implants Symposium

Another important aspect of hearing loss is music, a problem of particular importance to people with cochlear implants. Eriksholm Research Centre and Oticon Medical organized a **two-day symposium on Music and Cochlear Implants** with discussions covering a multitude of insights and hypotheses within outcome measures, rehabilitation, and processing. Providing an open environment for 90 researchers to meet and discuss the future of music perception and appreciation for people with cochlear implants is tremendously rewarding and something that we take great pride in being able to host.

EVOTION

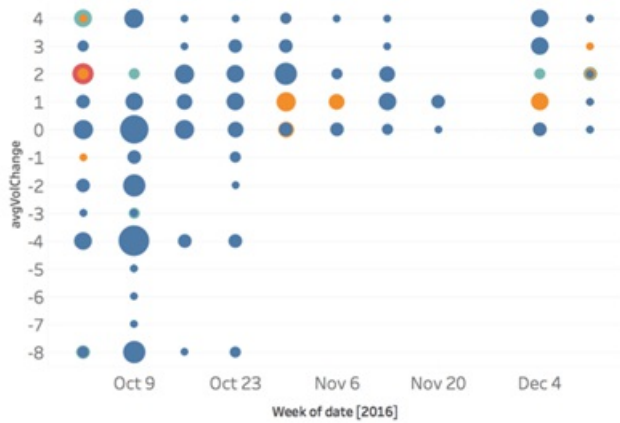
Together with our colleagues in the eHealth research group, we succeeded, in the highly competitive H2020 framework, to win funding for the 5 MIO EUR EU Horizon 2020 project **EVOTION** with 12 strong partners across Europe. The overall topic is big data and public health policies, and the consortium focuses on hearing loss as the chronic disease and smart hearing aids as a primary intervention. Recognizing that all treatments centre around the person with hearing loss in collaboration with a clinician, while at the same time the public health policies span many individuals with hearing loss, EVOTION connects stakeholders from end-users and clinicians, to public health authorities. The project started in November 2016 and runs for 3 years



EVOTION consortium in front of Eriksholm Research Centre at the kick-off meeting in November 2016

Optimizing the user experience

In a related project co-funded by the Copenhagen Centre for Health Technology (CACHET) we investigate and focus on optimizing the user experience for interacting with hearing devices. This project has already provided some interesting insights into how people utilize hearing aid technology, and it proves the huge benefit of being able to see how technology is being used in the real world. The CACHET and EVOTION projects mark a new area where the research takes place in the field where the hearing device is an active component in collecting the data. As researchers, we always rely on data, and the new possibilities to extend lab data with real world data is a huge step forward



Patterns in use of volume control for a single user over 12 weeks. This user seems to change behaviour after the first four and only increase volume hereafter

If you wish to read on, follow this link to [the Advanced Algorithm section of this website.](#)

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

In the Cognitive Hearing Science group our focus through 2016 and into the near future is "Hearing & Cognition". We are part of the big European Horizon 2020 project "Cognitive Control of a Hearing Aid" (COCOHA). The project has received strong, international attention and members of the CHS team have been invited speakers at numerous international conferences.



It is amazing to feel what "neuro-feedback" means for the Human Machine Interface. The CHS team demonstrates this with a "Restaurant Problem Solver" vision: 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 speakers are attenuated. It is 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.

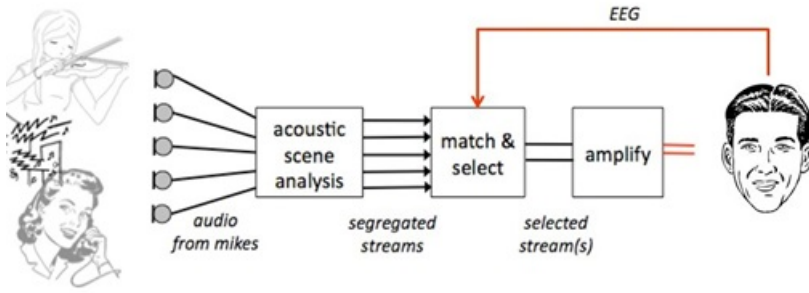
The reactions from hearing aid users trying this Restaurant Problem Solver have been ranging from "When can I have this?" to "It is so intuitive and easy, you really feel in control".

Imagine that one day, a hearing aid can read your mind and help you listen to what you really wish to hear. Moreover, 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.

After years of research within this field, our huge interest in the cognitive aspects of audiology has rapidly expanded to cover new exciting ways to assess hearing aid outcome. Methods like pupillometry and working memory have now showed their advantage in assessing hearing aids under more ecological, realistic daily-life conditions. In addition, new not yet seen cognitive hearing assessment methods are underway.

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 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. During 2016, the team was strengthened with a PhD student in collaboration with DTU (Antoine Favre-Félix) and two post docs (Alejandro Valdes Lopez and Tanveer Bhuiyan). Alejandro has a background in psychoacoustics and electrophysiology in cochlear implants, and he won the prestigious "Collin Cherry award" for his poster at the Speech in Noise (SPIN), 2016. Tanveer has an engineering background in electrophysiology and holds a PhD from Aalborg University. During 2016 the team was also strengthened with another post doc from Linköping University, Emina Alickovic, whose collaboration with Professor Fredrik Gustavsson makes it possible to merge completely new research areas such as sensor integration and system identification into the problem space of COCOHA.



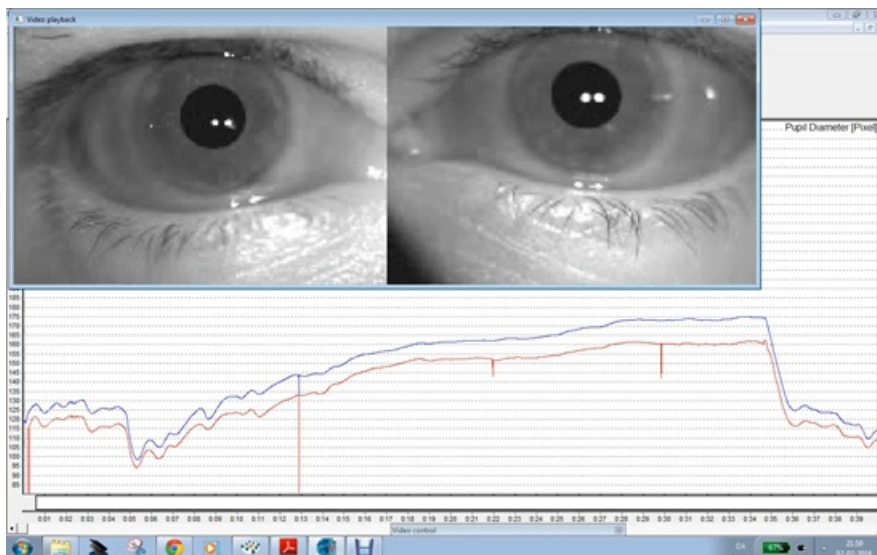
Cognitive hearing outcome methods for assessing hearing device outcome under real-world ecological conditions

The real world is not like a lab with controlled environments. Things move, targets of interest quickly shifts, listeners adapt to the conditions around them. In order to better assess hearing devices under these conditions we need to develop sensitive methods that reflects the cognitive and auditory challenges.

Listening effort under ecological conditions

During 2016 we have, in collaboration with VUMC Amsterdam, shown that hearing impaired spend more listening effort (as assessed with pupillometry) in conditions with fairly low background sounds where most of the speech is understood (ecological) and less listening effort at conditions with loud background sounds compared to age-matched normal hearing listeners. For more information on the use of pupillometry for assessing listening effort, please follow [this link](#).

These ecological findings opens up for evaluating hearing devices under important conditions which previously have been under-researched. During 2016 we showed that advanced hearing aid signal processing actually reduce listening effort under such ecological conditions. For more information, please see [this poster](#)



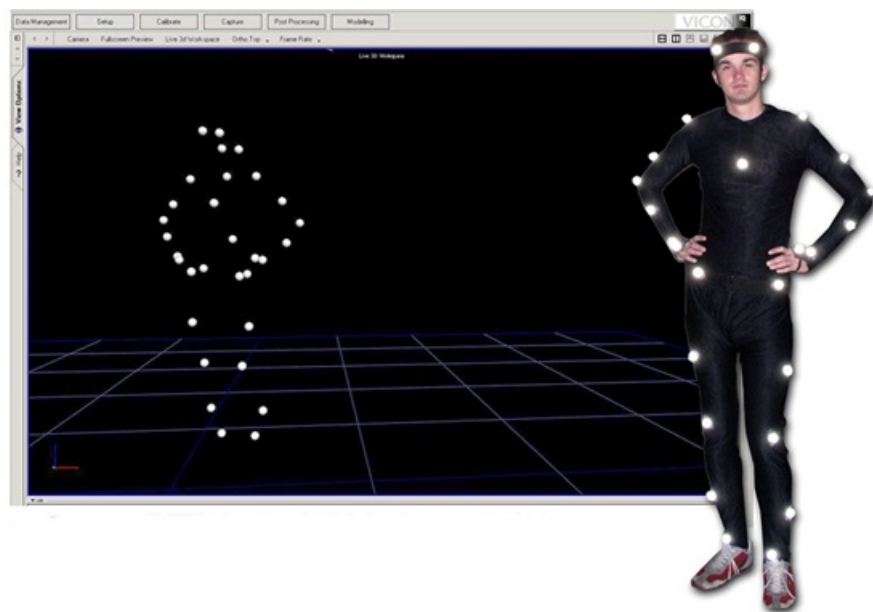
In addition, and also during 2016, Eline Borch Petersen (Industrial PhD student in CHS) showed that increasing hearing impairment has a consequence in how signals are encoded. With EEG recordings it was shown that the hearing impaired listeners encode attended and unattended signals equally much, while normal hearing listeners better encode the attended signal. This finding has far-reaching implications that we need to evaluate new methods to better understand it.

During 2016 we also had visits from MHH Hannover, where new ecological methods based on the SWIR test (working memory outcome) was developed for cochlear implants.

New methods for assessing real-world natural dynamic behavior

One way to better understand the dynamic behavior is simply to track the movements. We have

therefore invested in a motion capturing system that in real time follows the dynamic physical movement of a listener. With such a system, we can better monitor and model the movement behavior in situations where a listener quickly switch attention from one talker to the other.



Picture by courtesy of Vicon

If you wish to read on, follow this link to [the Cognitive Hearing Science section of this website](#).

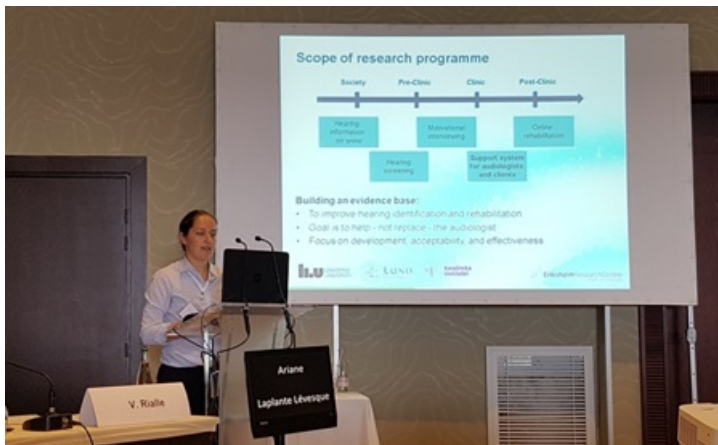
eHealth

Eriksholm's strategic research area, eHealth, is headed by **Ariane Laplante-Lévesque**

Learn more about **eHealth** on the Eriksholm webpage

Our strategic research area eHealth capitalises on information and communication technology (ICT) to improve hearing healthcare services. eHealth improves the flow of information within and around healthcare. To quote the World Health Organisation, "e-health can put information in the right place at the right time, providing more services to a wider population and in a personalised manner." Our vision is that eHealth will provide people with hearing impairment with better, more personalised care. All of our eHealth solutions take the needs of the patient, the family, and the hearing care professional into consideration. This helps secure adherence with the hearing treatment.





Presenting research results at the World Congress of Gerontechnology, Nice, September 2016

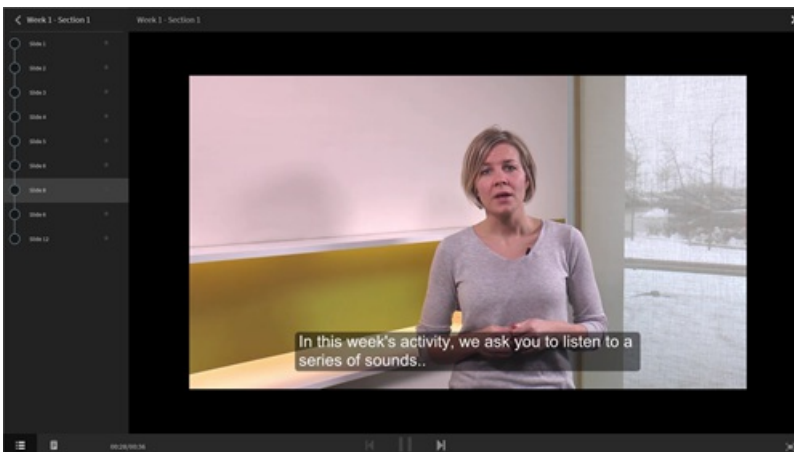
New colleague in eHealth



Sergi Rotger Grifol joined the eHealth group in August 2016. Originally from Barcelona Spain, Sergi holds a PhD in Computer Engineering from Aarhus University in Denmark. Sergi brings expertise in systems engineering, software development, and ICT. In 2016, Sergi jumped right in his new role by supporting the elicitation of user requirements in the **App(etite) for life with hearing loss project**.

Online Hearing Enhancement Program - an online rehabilitative intervention with Eriksholm Guide To Better Hearing

This project, led by Elisabet Sundewall Thorén, develops and evaluates an online program that aims to better equip hearing aid users so they experience fewer negative consequences because of their hearing. In 2016, focus was on the development and pilot testing of the program. In 2017, the program will be tested with National Health Service patients in collaboration with Melanie Ferguson, PhD and her team from the Nottingham Hearing Biomedical Research Unit.



Follow [this link](#) to read more about the project.

App(etite) for life with hearing loss

This project, led by Annette Cleveland Nielsen and financed by the Danish Ministry of Higher Education and Science's Agency for Science, Technology and Innovation, spans August 2016 to end 2017. This collaboration between the Eriksholm Research Centre and Professor Anne Marie Kanstrup from the University of Aalborg involves three target groups: hearing aid users, their significant others (family or friends), and hearing care professionals. It involves all three target groups to co-design innovative and empowering eHealth solutions. In 2016, 24 hearing aid users, 10 significant others, and 8 hearing care professionals shared their views.



Follow [this link](#) to read more about the project.

Health behavior change in adults with hearing impairment



In 2016, we completed our collaborative project with Gabrielle Saunders, PhD, and her colleagues at the **National Center for Rehabilitative Auditory Research**, Portland, Oregon, USA on modifying beliefs and attitudes that promote motivation for help-seeking for hearing. The project resulted in three peer-reviewed papers and were presented at IHCON and at the World Congress of Audiology.

Follow [this link](#) to read more about the project.

International Meetings on Internet and Audiology



University of Louisville · July 27-28, 2017

Born from the Eriksholm Research Centre's wish to facilitate international scientific exchanges in the rapidly developing field of eHealth, the International Meetings on Internet and Audiology have been a resounding success. The Eriksholm Research Centre has been organising these meetings together with colleagues from Linköping University and the University of Louisville. The first meeting took place in Linköping, Sweden in 2014 and the second meeting took place at the Eriksholm Research Centre in 2015. Special issues of the American Journal of Audiology were published after each meeting, summarising many of the presentations for the benefit of those who could not be present. Preparations are underway for the third meeting, which will take place at the University of Louisville KY, USA on 27-28 June 2017. Follow [this link](#) to read more about the upcoming meeting.

If you wish to read on, follow [this link](#) to the **eHealth** section of this website.

2016 in numbers

Follow each link to find out more.

19 papers published in peer reviewed journals

2 other papers

3 papers published in conference proceedings

15 Conference posters

22 conference presentations

Participation in 21 conferences

35 manuscripts reviewed for peer reviewed journals

Supervision of 6 students at Eriksholm Research Centre

Supervision of 13 students external to Eriksholm Research Centre

6 Examinings

459 citations of all publications from Eriksholm Research Centre (according to Elsevier

Scopus®)