Combining hearing devices with smartphones

Birger Kollmeier und Christiane Thiel: "The broad spectrum of interdisciplinary expertise makes the Cluster unique."

The starting signal for the Hearing4all Cluster of Excellence came three years ago. How much progress have the scientists made? What are their ultimate goals? Birger Kollmeier, coordinator of the Cluster of Excellence, and Christiane Thiel, lead researcher, on combining hearing devices and cochlea implants, the internationalisation of Oldenburg standards and solutions for those for whom a hearing aid is too much, but no hearing aid at all is too little

The starting signal came in November 2012 – five years of funding for the Cluster of Excellence Hearing 4all. Mr. Kollmeier, you are the Cluster's coordinator. Where does Hearing4all stand at the half-way mark?
Kollmeier: It's always hard to make an interim assessment. The sheer number of tasks involved was and still is overwhelming. But after two-and-a-half years we are able to say that the majority of the problems we wanted to tackle, we have indeed tackled – and in most cases we have already achieved substantial success.

Hearing research in the Cluster of Excellence can be roughly divided into three fields: improving hearing aids, basic research for assistive audio technology and improving diagnosis to provide better individual treatment. What have you achieved in diagnostics, for example, and in what direction is it headed?
Kollmeier: We are looking into how sound is actually processed – from the perspective of neurobiology, psychophysics and neuropsychology for example. Building on this we have developed new ways of tying up the basic research with clinical requirements, the treatment side of things, in other words. We have developed diagnostic methods which already establish international standards, the "Oldenburg Sentence Test", for example, which exists in 21 languages.

Can you give a specific example of how you have improved treatment through diagnostics?
Kollmeier: Something that has come on in leaps and bounds recently is combining cochlea implants and hearing aids. Either on one ear so that the person hears high frequencies with the implant and low ones with the hearing aid. Or they have a cochlea implant in one ear and a hearing aid on the other. These therapeutic possibilities have only been developed in the past three years – and we have provided the underlying diagnostic basis and criteria for this. However it is not yet possible to develop the right therapy for each and every patient at the flick of a switch or even for this to be implemented globally as a software solution.

Is this a long-term goal?
Kollmeier: Absolutely. We want the standards we have developed here to be used internationally. Our internationally compatible language tests are a particularly important vehicle in this respect. By using them other scientists and partners worldwide draw on our experience and we can distribute our standards internationally.

... and at the same time presumably gain access to a much larger amount of data.
Kollmeier: Thanks to internationally comparable tests, all of a sudden data gathered in Russia can be compared directly with test-subject groups in other countries. For example a junior researcher in Finland translated the Oldenburg Sentence Tests into Finnish and used them on a patient with cochlea implants. Now his findings can be used as a comparison in 21 other language areas. This sort of thing was not possible before.

Ms Thiel, you are not involved with the Sentence Test specifically, but as one of the Cluster's principal investigators you also work in diagnostics. What is your approach there?
Thiel: Our goal is to individualise diagnostics. So are there factors, beyond simple hearing loss, that can help ex-

Prof. Dr. Dr. Birger Kollmeier

Physicist and physician Birger Kollmeier is coordinator of the "Hearing4all" Cluster of Excellence and also head of the „Medical Physics" department, the Hörzentrum Oldenburg GmbH and the Fraunhofer Project Group for Hearing, Speech and Audio Technology. Kollmeier has received a number of prestigious awards, including the International Award of the American Academy of Audiology and the German President's Award for Technology and Innovation.

plain why the quality of hearing in patients varies so much? Not everyone benefits from a hearing aid or a cochlea implant. Not just auditory but also cognitive factors may well play a role, for example, in how well someone is able to direct their attention to a speaker or how long their memory span is. On the one hand I observe these things on a purely behavioural level like other scientists in the Department of Psychology, but of course we are also interested in the extent to which brain activity potentially contributes here.

How has your field developed since the Cluster of Excellence began? How have the possibilities for your research expanded?

Thiel: One thing that makes a huge impact at this location is our two brain imaging devices – few institutions have both in one place, and they open up exciting questions for us. The MRI scanner that I work with allows us to localise processes in the brain. And the magnetoencephalograph provides us with the temporal resolution. This means we can examine the same patient in both machines and gain an optimal comparison of the temporal and spatial dimensions. That is one aspect which substantially strengthens Oldenburg as a scientific location, even beyond the Cluster of Excellence.
Kollmeier: And as well as about the machines it is also above all about the people. We have a very good mix of cooperating scientists who share the same methodology but approach the matter with very different research interests. In recent years, for example, the cognitive neuropsychology aspect has very much come to the fore. We were blind to this aspect before. Ms Thiel and the other scientists have classified our test subjects also according to central functions so that internationally we now have the best characterised stock of test subjects. This means we can run studies in Oldenburg that simply don't exist in any other locations.

The second field of research is better hearing devices. What is the current status here?
Kollmeier: We set out to demonstrate the principle feasibility of better hearing devices and to improve the systems technology. Our vision is to have a bit of Oldenburg in all hearing systems in ten years' time. The prototype development is highly successful. Using demonstrators we can show the advantages of binaural – or two-ear – hearing and of scalable algorithms. The first patent has just been registered for a device that that may be turned from an assistive listening system for very slight hearing impairments right into a fully functional hearing aid by button press. There have also been technological advances in cochlea implants.

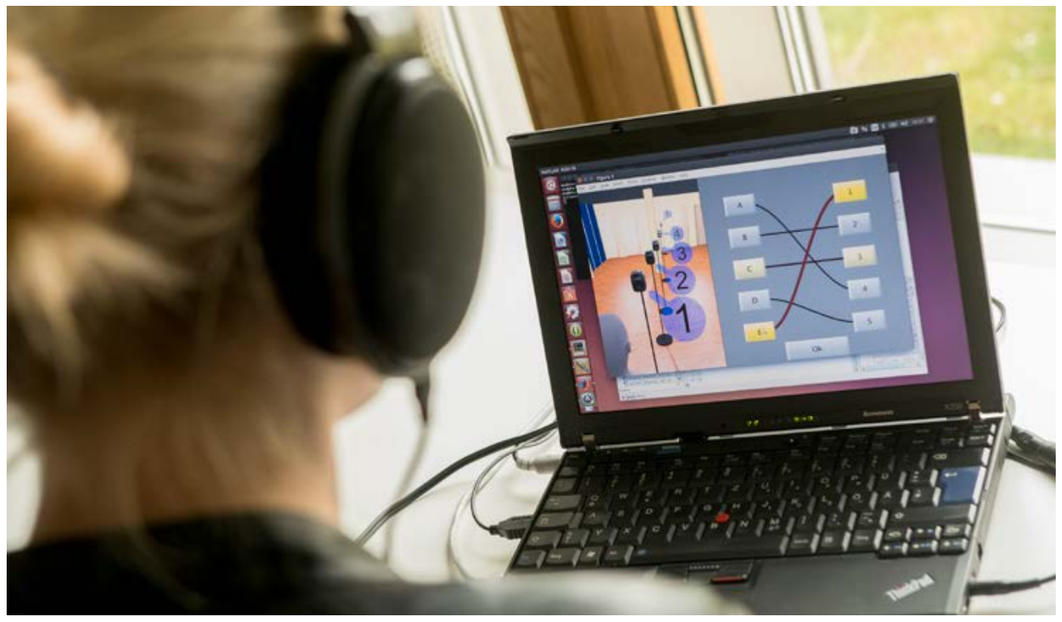
> **"Our advantages: entrepreneurial spirit and unpretentious collaboration"**
> Birger Kollmeier

What role does individualisation play?
Thiel: The goal is to adjust the function of the hearing device on the basis of individual diagnosis. For example researchers have found out that when hearing-impaired patients use a hearing aid for both ears simultaneously, loud volumes in particular are heard much louder than was previously assumed. Up to now this binaural accumulative effect was not taken into account when adjusting hearing aids. They were adjusted to each ear individually, which meant patients would find the volume too loud. So then the whole hearing aid was turned down – making it too quiet at lower volumes. Studies carried out here in Oldenburg have demonstrated that binaural hearing must be taken into account to a far greater extent than it has been in the past. It may be possible to lay the foundations for this in the next two years.

And how are things going in the third field of research, basic research into assistive audio technology?
Kollmeier: On the one hand we are trying to find solutions for people for whom a hearing aid is too much but no hearing aid at all is too little – and in general to integrate human-machine interfaces into audio systems. In the area of speech recognition, for instance, we have been very successful. But we are also moving in the direction of brain-computer interfaces, where we are trying to use EEG signals to help control hearing devices. Once again neuropsychology plays a key role here.
Thiel: That's Professor Stefan Debener's research group, which has developed very interesting measuring techniques. Basically we're talking about mobile measurement of electrical brain activity – but in practice no one would want to walk around campus wearing a conventional EEG cap. So the group is trying to make these devices smaller and smaller and has reduced the electrodes to the point where they can simply be stuck behind the ears. This makes them completely unobtrusive, but they can still measure brain activity.
Kollmeier: With that innovation Stefan Debener and his team have taken the global lead within just two and a half years. It's very impressive to think that in the future we may be able to operate hearing aids and similar devices on the basis of such mobile EEGs.
Thiel: Mobile recording techniques are one issue here. But brain-computer interfaces based on EEG technology are still very slow and unreliable. That means we will need a lot more processing power. This is why we now have our own expert on machine learning, Jörg Lücke, who uses algorithms and statistical classification to analyse the brain signals and deduce what the person wants to do.

What is your vision for this field of research? What do you want to achieve?
Kollmeier: Basically we want both technological and systems competence. Systems competence also means knowing how humans function and what they need, so in the future we can radically improve and support user-friendliness and practicability in hearing-related solutions. That means creating and controlling all the prerequisites for us being able to find solutions that are not possible today, but are already visible on the horizon.

Can you name an example?
Kollmeier: Hearing devices combined with smartphones for example. Our vision is that in a few years' time every smartphone will contain Oldenburg technology, in the form of an app, say, that helps the user to hear specific things more precisely.



"Not everyone benefits from a hearing aid or a cochlea implant." A test subject in the hearing lab.

Prof. Dr. Christiane Thiel

Prof. Dr. Christiane Thiel leads the "Biological Psychology" research group and is examining the role of neurotransmitters in cognitive processes. In the "Hearing4all" Cluster of Excellence she leads the "Functional Characterisation of the Individual" task group, which is researching why individuals process acoustic stimuli differently – and why not everyone benefits equally from a hearing aid.

Without a hearing device?
Kollmeier: Well for example I would have a small button in my ear, similar to a bluetooth headset for listening to music, and it would enable me to use hearing device technology without it really being distinguishable from a standard consumer audio device. So even people with normal hearing would benefit considerably from the technology as they go about their everyday lives, whether it's because it provides a kind of "enhanced reality" that makes certain sources more audible or because it gives them access to additional information channels via more or less conscious control, via gestures or brain-computer interfaces. So we would be the leading system address for all future applications related to auditory perception.

What do you personally enjoy most about your work with the Cluster of Excellence?
Thiel: The interdisciplinarity. This often gives you completely new ideas. For example I wouldn't normally go to engineering lectures – but there you get to see things from an entirely different perspective. So it make as lot of sense that so many different disciplines are involved in the cluster. This broad spectrum of expertise makes it unique.

> "We would like to involve our medical colleagues working in the hospitals here in Oldenburg"
> Christiane Thiel

And your hopes for the future?
Kollmeier: I want the cluster to continue to develop stably. Naturally it would be good if the funding period was extended, but that's still open. We would like to carry on with the structures that have already been put in place …
Thiel: … and also involve our medical colleagues working in the hospitals here in Oldenburg. When the project began we brought in colleagues from Hannover because we didn't have a medical faculty here. Now more and more professors are coming to Oldenburg and are expanding the local spectrum.
Kollmeier: We don't have the mass of traditional universities with their huge engineering and medical faculties. But our advantage is a certain entrepreneurial spirit and unpretentious collaboration which quite naturally crosses the boundaries between different disciplines. This is the only way to make progress. And preserving it is crucial – also for other areas at the University.

Interview: Dr. Corinna Dahm-Brey, Matthias Echterhagen, Deike Stolz

In front of the new NeSSy building: "Two large machines – an MRI scanner and a magnetoencephalography scanner – open up new research questions for us."

Smart and space-aware

Physicist Volker Hohmann and his team are working on the hearing devices of the future. And on virtual realities that help put these intelligent, space-aware hearing aids to the test

Several members of Volker Hohmann's research team recently once again spent a large part of their working week in the university cafeteria. Hohmann made no attempt to stop them – quite the opposite in fact. Hohmann, Professor for Psychoacoustics and one of the leaders of the Oldenburg Research Unit "Individualized Hearing Acoustics" funded by the German Research Foundation (DFG), actually seems delighted. Because the cafeteria on Wechloy Campus – in the form of a virtual three-dimensional model, please note – belongs to the team's research territory. "Every added detail brings reality a little bit closer," Hohmann says.

So what makes the cafeteria between the Maths and Physics wings so interesting for hearing research? It is a complex audio environment with diverse sound sources from different directions. To have a conversation there – potentially with a group of people – amidst the clatter of cutlery and mobile phone calls, requires excellent hearing. But as long as they function properly almost no one thinks about the complex processes in the ear and brain that transform sound sources into "heard information", filtering out what is important to us.

Yet almost one in six people has limited hearing – and plenty of people who have normal hearing now will be confronted with hearing impairment in the future. They all stand to benefit from Hohmann's work. Together with his team he divides his time between developing virtual realities (VR) that simulate environments like the aforementioned cafeteria or a busy train station with both images and sound in the laboratory, and following on from this, developing smart hearing devices that are able to analyse complex acoustics and also identify what their wearers wish to hear.

On a Monday morning in May we meet at NeSSY, the new research building on Wechloy Campus. In his office on the third floor Volker Hohmann, who is also the leading researcher in the Cluster of Excellence "Hearing4all", lays his cycling helmet on the windowsill. One of the walls is lined with boxes of books and folders. There has been little time to unpack them in recent months, as research and setting up the new laboratory rooms have taken priority. A visit to the new building provides a glimpse of the technical