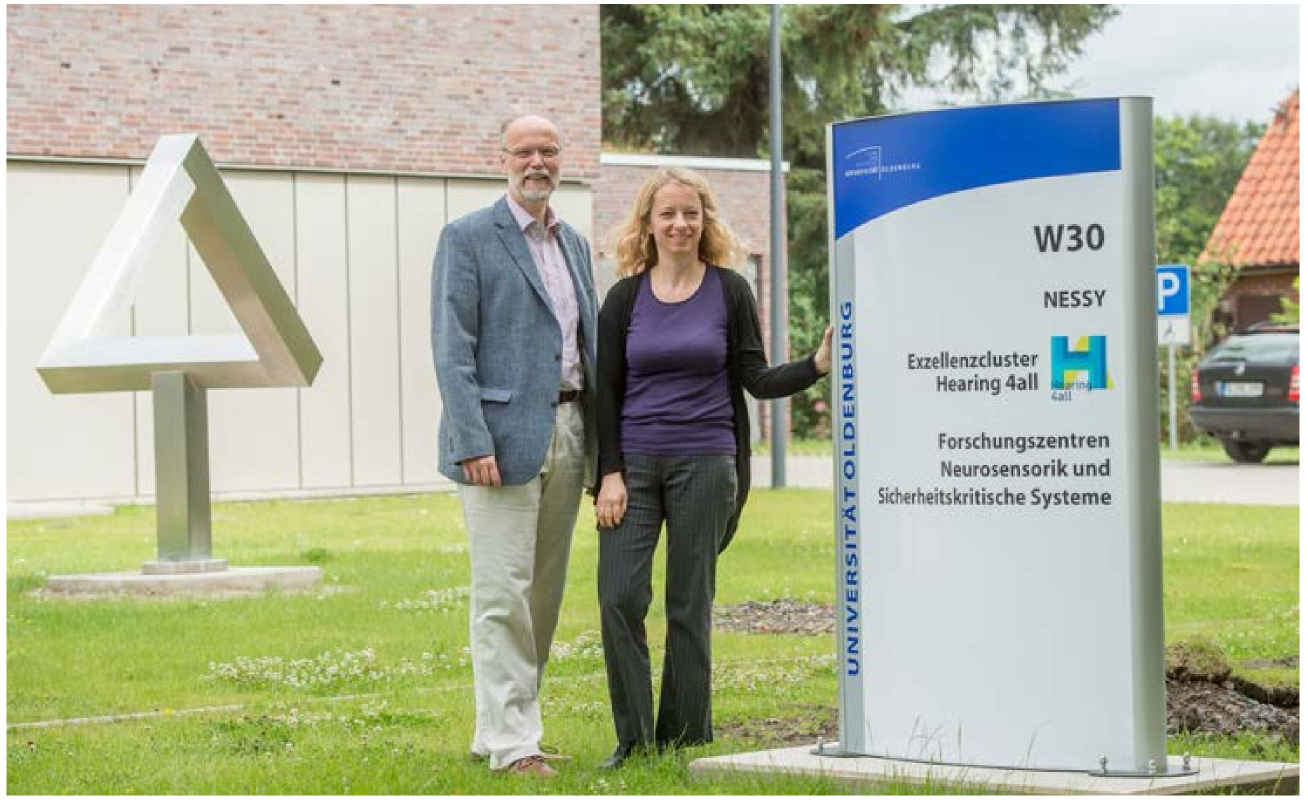
Without a hearing device?
Kollmeier: Well for example I would have a small button in my ear, similar to a bluetooth headset for listening to music, and it would enable me to use hearing device technology without it really being distinguishable from a standard consumer audio device. So even people with 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

The university cafeteria as research terrain: as virtual reality on a computer terminal in the NeSSy building's foyer and on the screen in the laboratory, as well as during a quick midday visit by hearing researcher Prof. Dr. Volker Hohmann to the real "terrain".

refinements on offer at NeSSy – including a state-of-the-art VR room which the physicist's team is currently setting up.

This new high-tech laboratory has arrived in perfect time for the second phase of his work in the DFG Research Unit, Hohmann explains. "After three years spent developing new research tools, it is time to start harvesting the fruits of our labour. We are now implementing our findings – like new methods for testing hearing devices – so that in another three years' time we can reach a preliminary conclusion for this phase of the project." Hohmann's aim is to create smart, "space-aware" hearing aids.

"Spatial perception and naturalness – smart devices should deliver both"

Three floors down on the ground floor is a corridor full of laboratories. The VR room is a particularly interesting example: an anechoic room lined with foam wedges to minimise sound reflections. On entering you find yourself standing on a metal grid below which more foam wedges cover the floor. Loudspeakers are arranged concentrically around the centre of the room. A scientist is hanging more from the ceiling. The room will eventually hold 94 loudspeakers to simulate complex audio situations in high quality, and these will be visualised simultaneously on a 180 degree screen.

Nineteen speakers placed towards the top and bottom of the room respectively will simulate the vertical reflection of sounds as well as potential sound sources from these directions, such as might arise while taking the escalator in a multi-storey shopping mall. The main ring of 48 speakers placed horizontally at head height surrounds the screen and targets directional hearing at the horizontal level, which is not only more sensitive but is also particularly important in complex conversational situations.

It is in such situations that conventional hearing aids come up against their limits, explains the 52-year-old Hohmann, back in his office again: "They suppress disruptive sounds and amplify whatever is happening right in front of your nose. This forces the user to fixate on the speaker's lips, and even to tilt their head in exactly the direction they want to hear from." This means that static forward-oriented hearing aids actually impair the natural conversational behaviour that people with slight hearing difficulties in particular want to maintain. What's more, the spatial impressions they deliver are poor. "Spatial perception and naturalness – smart devices should deliver both," Hohmann emphasises.

This is precisely what he and his team hope to achieve, and they are already working on a dynamic hearing device. It is gesture-controlled, and as such should be able to recognise what each individual wearer wants to hear by factoring in their eye and head movements. This is considerably more advanced than the binaural – two ear – acoustic analysis which Volker Hohmann co-developed and which won the 2012 German Future Prize. “Because these devices are often unable to identify which of all the possible sources in an environment the patient wants to hear at any given moment.”

Two new technical elements are to change that. One is an acceleration sensor, similar to the ones that allow smartphones to rotate photos on the display in line with the device. In hearing devices it will register head movements. The other is another sensor, which, just as electroencephalography (EEG) measures brain waves, uses so-called electrooculography (EOG) to measure the electric fields of the eyes. Oldenburg neuropsychologist and EEG sensor expert Prof. Dr. Stefan Debener is also involved in this. He is working in the lab to refine the technology that recognises the direction of a test subject's gaze.

"Eye and head movements are actually pretty easy to measure – even in a hearing aid worn behind the ear," Hohmann explains. "They also help to tell us what the hearing aid wearer is doing: Which direction is he looking in? How is he moving his head?" And this is critical when it comes to moving beyond the conventional "head-oriented" hearing aids to space-aware devices. Static hearing aids are completely unable to differentiate between a wearer turning his head and sound sources circling around the wearer's head.

"The aim is to educate young researchers, to open up spaces for them. That is what universities are for"

The dynamic hearing device of the future, however, will be able to adjust to the specific behaviour of the person wearing it. Its ability to factor in the direction of the gaze will be particularly useful to patients who use their eyes in conversation but who barely make unconscious movements with their heads. "We call these people 'lazy'," Hohmann says. He explains that between these 'lazy' people and those who literally hang on the lips of others and are therefore permanently moving their heads there are many different levels of unconscious, individual conversational strategies.

Hohmann's laboratory is increasingly conducting research into such strategies. "We use virtual reality to test hearing devices, but also to observe how test subjects behave. This is providing us with a comprehensive picture of the interaction between user and environment," Hohmann explains.

The multidisciplinary approach enriches his research – besides computer scientists, acousticians, engineers, physicians and neuropsychologists, a doctoral student from sociology who is categorising and systematically analysing behavioural observations recently joined the research. "We are adapting methods from other disciplines for our hearing devices. It would make little sense to do everything ourselves," Hohmann stresses.

Instead he actively invites other experts to use his tools. "We come together on one level, each person bringing their own methods to the table, and we see what this achieves. Often it produces concepts that are new to us, but that's what makes it interesting." So his own role – besides programming acoustic tools and scientific publishing – mostly involves communication with the participating scientists. "How can we bring different disciplines together and integrate them to achieve the goal of building better hearing devices?" Hohmann sees himself to a certain extent following in the footsteps of the famous physicist Hermann von Helmholtz, an acoustics pioneer and 19th century polymath who had no fear of looking beyond disciplinary boundaries.

His research group "Auditory Signal Processing for Hearing Devices" consists primarily of engineers and physicists – and Hohmann is strongly committed to mentoring his PhD students and working with them on individual research plans. "It is a step-by-step process that varies according to the individual requirements and qualification interests. The aim is to educate young researchers, to open up spaces for them to fill with their creativity and motivation. That is what universities are for," Hohmann says. As project manager it is his job, he explains, to combine long-term research objectives with the naturally often short-term qualification objectives of his fellow researchers.

For Hohmann "HörTech", the centre of competence for hearing device systems engineering which was co-founded by the university and where he acts as area director for research and development, is invaluable for consolidating and utilising the various findings of his PhD students. His function there, he says, is to bring together the various findings, for example from dissertations, and integrate them into a larger whole. "Otherwise you might get the odd paper, but to integrate all the work, to be able to say that we have genuinely improved a hearing device – that cannot be achieved through PhD theses alone. That's why we need this transfer facility."

While HörTech is constantly working on implementing new findings and seeking commercial applications, Hohmann's research with his team at NeSSy is different, he explains: "We don't produce hearing devices – we create and open up possibilities." Even on trips to the campus cafeteria. (ds)