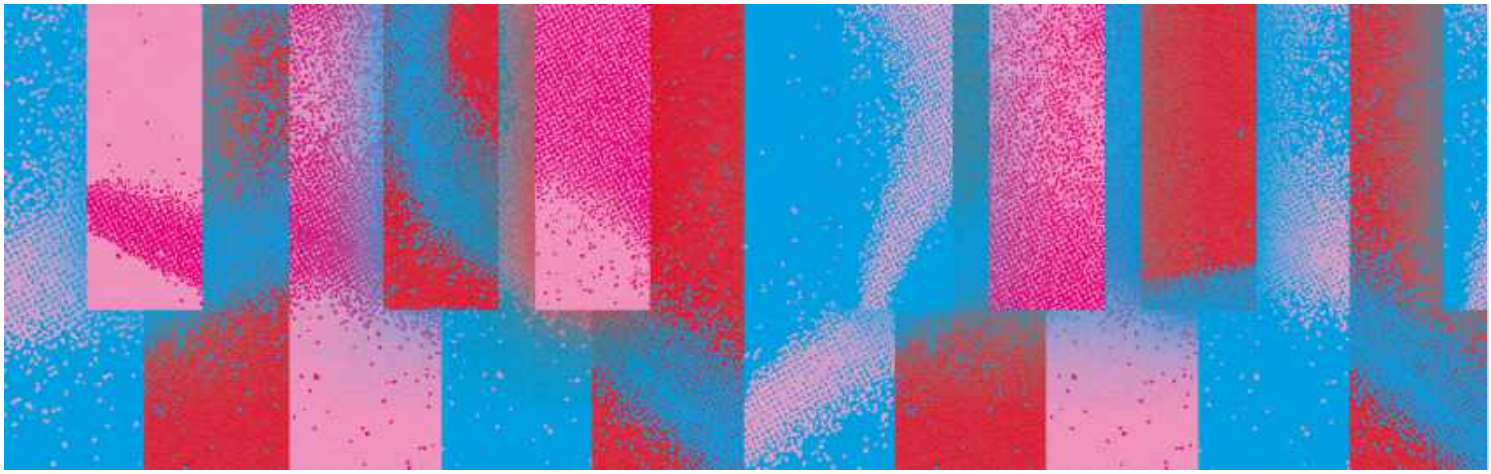

Theme
sound and noise

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About listening and belonging

Fadhel El May is researching a new generation of cochlear implants – they could revolutionize hearing with implants. But El May is not only a scientist, he is also affected himself: he has been severely deaf since birth.

Hungry people rummage through cutlery drawers, trays clatter on tables and conversations waft through the room, merging into a single loud murmur. Fadhel El May cannot hear any of this, but it is still extremely stressful for him. For him, it is a lump of noise, a mass of background noise. While his colleagues chat relaxedly about their weekend in the canteen of the University Hospital of Göttingen, Fadhel El May switches off his electronic cochlear implant. He has been hard of hearing since birth, and in situations like these he relies entirely on lip reading to understand the person he is talking to.

Fadhel El May suffers from congenital profound inner ear hearing loss. Although he wears a cochlear implant, he often relies on lip reading in his everyday life. This works best when the person he is speaking to is communicating in his native language, French. But he can now read English quite well too.

Fadhel El May is 32 years old and is doing his doctorate at the *Institute for Auditory Neuroscience* at the University of Göttingen. There he is part of an interdisciplinary team consisting of over 80 scientists. They all have a common, overarching goal: they want to develop a new generation of cochlear implants. The idea behind it: hearing with light. These so-called optical cochlear implants could significantly narrow the gap between the world of the hearing and that of the deaf. That is the hope - not only of Fadhel El May and his

colleagues. An estimated 450 million people worldwide are hard of hearing, 16 million in Germany alone. The new technology could offer them a much greater variety of sounds.

Between two worlds

In the canteen of the university hospital, Fadhel El May is once again devoting himself to his lunch. He finds it difficult to follow the conversation at the table. "It is particularly difficult for me when people are talking at the same time in a noisy environment," he says. It is a bit like a group conversation in a foreign language. You sit at a table with native speakers. A sentence is said, a joke, everyone laughs. By the time you have understood the joke, the others have long since moved on to the next topic. Fadhel El May often uses a trick: he starts a new topic of conversation when there is a pause. Then he knows what it is about, and it is easier for him to follow. "But sometimes I don't want to disrupt the flow," he says. When he notices that a certain dynamic has developed, the sentences are being shot through the air like balls, he finds it difficult to interrupt the others and say that he doesn't understand anything.

»Sometimes I feel like a wanderer between worlds« Fadhel El May

"This feeling of not really belonging is deep-seated," he says, remembering a moment in elementary school: his teacher was playing the piano, surrounded by the class, everyone singing along. Even though he can't remember how old he was at the time, he remembers exactly what happened next: the teacher stopped the game, her gaze wandered over the crowd of children, the question in her eyes: who is singing so badly that they're messing everything up? He stopped at Fadhel El May, she pointed at him and said: "You. I don't think that's going to work. Would you like to go to the library while we practice singing?"

When Fadhel El May makes a phone call, his cell phone is connected directly to his cochlear implant. Outside noises then no longer reach him. This can be helpful when working in the open-plan office at the Institute for Auditory Neuroscience in Göttingen. Fadhel El May is researching optical cochlear implants as part of an interdisciplinary team.

Fadhel El May went to the library. Singing is almost impossible when you can't hear yourself. Even though he understood that, the story still makes him sad today. At the time, he didn't have a cochlear implant, but wore two hearing aids that only amplified the sounds of his surroundings. He was born severely deaf, just like his brother, who was one and a half years older than him - a genetic defect. "It was a shock for my parents at first," says El May. Both have normal hearing and suddenly found themselves faced with two little boys who had great difficulty speaking and understanding. And they were faced with a big decision: "Do we teach them sign language and send them to a school for the deaf? Or do we try to integrate them into the world of the hearing?", says Fadhel El May, describing the dilemma. They chose the latter.

A new opportunity: the cochlear implant

For many years, Fadhel El May got by by reading lips and picking up the few scraps of sounds that reached him. With a lot of support, he says, he managed to attend a normal school. He read what the teacher was saying on the blackboard from the lips of an interpreter. He also practiced speaking with a speech therapist. "I couldn't really hear the s and sh sounds and couldn't say them properly either," he remembers. But he also sees the positive side: "My poor hearing meant that I had really good friends," he says. Those who made an effort to interact with him were caring people who didn't care much about superficiality. During this time, friendships were formed that have lasted to this day. "I couldn't have anything to do with the others. And I didn't want to either," he says.

But over time, Fadhel El May - like his brother - heard less and less, a consequence of the genetic defect. Doctors first implanted a cochlear implant in his brother. "Suddenly he understood much more and had more social contacts," says El May. That's when El May, who was 16 at the time, knew: "I want that too." He still remembers the moment when a doctor in a Geneva clinic activated his implant in great detail.

The raindrops hit the roof of the car and all El May heard was: beep beep beep.

At first, all Fadhel El May heard was beeps. Every word spoken: beep. Every chair that was moved: beep. "Afterwards, my mother drove me home from the clinic and it was raining," remembers Fadhel El May. The raindrops hit the roof of the car and all El May heard was: beep beep beep. At first he found it disturbing. "It's not like you might imagine: you put in the implant and hear immediately," he says. Rather, the brain is damaged and the patient is initially disturbed.

Practice, practice, practice

While a conventional hearing aid acts like an amplifier for the sound waves, an electronic cochlear implant works fundamentally differently. With intact hearing, the sound waves move the air in our ear canal and cause our eardrum to vibrate. The faster the eardrum moves, the higher the sound, the slower, the deeper. The tiny auditory ossicles hang from the eardrum: the hammer, anvil and stirrup. When the eardrum vibrates, they vibrate. The chain of these ossicles forms a bridge to the entrance to the inner ear. This is where the cochlea is located. This twisted ossicle is the heart of the inner ear: when sound is applied, everything here is in motion. The fluids and membranes in the cochlea vibrate. Depending on the pitch and

intensity, certain sensory cells are mechanically stimulated there, the hair cells. These convert the mechanical stimulus into an electrical signal, which in turn activates docked nerve cells, the auditory nerve. This transmits its impulses via the auditory pathway to the brain. We listen.

With an electronic cochlear implant, most of these steps in the inner ear are skipped: A sensor attached to the outside of the head converts the sound signals directly into electrical signals. A small wire in the cochlea equipped with electrodes then transmits these electrical signals directly to the cells of the auditory nerves.

Immediately after an implant is inserted, the brain cannot do anything with this electronic information, as was the case with Fadhel El May. The only way to counteract the constant beeping is to practice. Wear the implant as often as possible. After months, Fadhel El May slowly began to understand more and more. "I will never forget the moment when I first understood what the teacher was saying on the board without looking at my interpreter," says El May. "A new world opened up for me then."

Meter by meter

The question of where he belongs still remains. He still doesn't understand a good third of the sounds around him. Certain things, like singing, remain out of reach. With his cochlear implant, Fadhel El May can't hear melodies either, only rhythms. "I would love to know how people with intact hearing perceive music," he says, comparing it to a piano. An intact hearing can distinguish all the keys and recognizes harmonies, for example that of a triad. With a cochlear implant, it's like playing with your fists, or even with your forearms.

"Sometimes I feel like a wanderer between worlds," says Fadhel El May. He doesn't really feel like he belongs with either the hearing or the deaf. Nevertheless, he is grateful for the implant, which took his sound world to a whole new level and made many things possible for him: He moved away from home, studied bioengineering and went to Harvard University in the USA for a year on an exchange.

"It's incredible what people who are severely hard of hearing achieve in their everyday lives. How many extra meters they walk to take part." Tobias Moser

There, at a conference, he met Tobias Moser - neuroscientist, ENT doctor and director of the Institute for Auditory Neuroscience in Göttingen. Fadhel El May is currently writing his doctoral thesis here, with Moser supervising it - and is impressed by his doctoral student. "He is a really talented social guy. You notice how carefully he reacts, how he interacts with people." Tobias Moser knows from years of experience with patients that people with hearing loss have a harder time in every area of life: "What people who are severely hard of hearing achieve in their everyday lives is unbelievable. How many extra meters they walk to take part."

A light switch for the cell

Moser is a tall, slim man who has something encouraging about him, as if he wanted to say: There are no stupid questions. He is very good at explaining complicated things in a simple way, for example how to genetically modify a nerve cell so that it becomes sensitive to light. He then simply says: Install a light switch in the cell.

Because that is exactly what so-called optogenetics is all about, i.e. the mechanism behind an optical cochlear implant that Fadhel El May and his colleagues are researching. Instead of using electrical impulses, the auditory nerves are to be stimulated by light signals. To do this, a processor first breaks down the sound into frequency bands, as with an electrical cochlear implant. With an optical implant, however, it breaks down sound into finer and many more. 64 light guides, which are assigned to the frequency bands, then guide the light into the inner ear. There, in the cochlea, the light then falls on the sensory cells. To avoid making the explanation too abstract, Tobias Moser uses a model of the optical cochlear implant. It stands on his desk and lights up whenever someone says something; a small microphone behind an oversized plastic ear picks up every word and every sound. The cochlea is transparent in the model and easy to see. Blue LEDs are arranged in a spiral shape, sparkling in the rhythm of Moser's explanations. It shows that converting sounds into light works. Now these "light switches" are needed in the cells of the auditory nerve. Using genetic engineering, the Göttingen researchers introduce the genetic blueprint of certain proteins into the cells. The nerve cells thus incorporate the light sensor into their membrane. As soon as light falls on it, it opens its gates, ions flow in, and the cell becomes electrically active. "This is how their impulses are transmitted to the brain via the auditory pathway," says Tobias Moser. Animal experiments show that installing the light switches also seems to work. Fadhel El May and some colleagues are now testing the interaction of the two components in gerbils.

If this succeeds, a milestone would be reached. "The light pulses could make the sound of speech and music much more natural and rich in nuances," says Moser. This is because an electronic cochlear implant tries to reproduce all sounds using twelve to 24 electrodes. An optical cochlear implant, on the other hand, could, at best, give 128 light pulses.

The cochlea +

How the electronic cochlear implant works +

How the optical cochlear implant works +

A special collaboration

Fadhel El May hopes that one day he will be able to wear an optical cochlear implant. Until then, he is proud to be able to contribute to this research. But he is not the only one making an effort. "A system like the university also has to adapt to support him," says Tobias Moser.

Fadhel El May and his colleagues insert the implants into the gerbils in a so-called "soundproof chamber." The cabins are soundproof to ensure that no disturbing noises distort the results during the acoustic experiments.

Bettina Wolf is one of those people who regularly walks a few extra meters with Fadhel El May so that he can take part. But she emphasizes: "Fadhel and I have learned a lot *from each other* ." She is currently sitting in a somewhat bare meeting room that exudes the typical charm of a hospital. Her big blue eyes and colorful scarf act as splashes of color against the white walls. This is where the whole team meets later. Bettina Wolf supervises some of Tobias Moser's doctoral students. Strictly speaking, she is one title above Fadhel El May; she has already completed her doctorate. When Moser and El May have a meeting, Wolf comes a and writes minutes for El May, because he can't listen well and take notes at the same tin

"And now I do the same for the other doctoral students I supervise," she says. It is one of the things she has adopted from her collaboration with Fadhel El May. What remains special is that Wolf discusses the minutes with El May afterwards. On the one hand, it is about the content, on the other hand, about subtleties in the voice. Because melodies not only make music, but often also the mood. "We are not aware of how much information we get from the tone of our counterpart's voice," says Bettina Wolf. Is the person sorry, angry or disappointed? "Fadhel sometimes doesn't notice the mood in the room very well," says Bettina Wolf. Then she helps him to assess situations. She then says: "Hey, Tobias really wasn't that happy about how things went." Or: "You noticed that Tobias was sorry about how things went?"

He then sits in the audience, his ear is at the front.

Now the other team members come into the meeting room; Bettina Wolf's small group meets very regularly. They gather around the meeting table. Fadhel El May puts a small microphone on the table. It is directly connected to his implant. He explains: "It's as if my ear is now lying here on the table. And when someone picks up the microphone and speaks into it, it's as if they are speaking directly into my ear." Fadhel El May also uses the microphone during lectures and places it right next to the lectern. He then sits in the audience, his ear at the front. At the same time, he can turn it off; he is then surrounded by absolute silence. In the open-plan office, his colleagues almost envy him for this: "Noise cancelling next level," says Bettina Wolf. In moments like these, Fadhel El May enjoys being able to isolate himself. In others, he needs help.

Working together to achieve our goal

In February 2023, he flew to a conference in Orlando with some colleagues. His girlfriend came along too, and they went to a theme park, Universal Studios, with her on a free afternoon. The two got on one of the fastest roller coasters in the park: "the Hulk," which goes up to 100 km/h. "We sit down, I take off my glasses so I don't lose them," says Fadhel El May. 3...2...1... the countdown roared through the air. Then the vehicle sped off, El May holding his glasses tightly in his hand. But the implant - "it was still connected to my head," says Fadhel El May. He felt it coming loose. "Right at the beginning there's a loop, I tried to grab it somehow, but you're strapped into your seat very tightly," he says. It flew down. "When we got to the end, I was completely distraught. I stood up and shouted, stop, we have to stop the rollercoaster," he laughs a little today as he tells the story. But the implant was gone; a processor like that is worth around 12,000 euros. "That was really an expensive

rollercoaster ride," says his colleague. "But how did you get it back?" Bettina Wolf interjects, "don't tell me that!"

His entire team came to the amusement park to look for the implant. They went to the site where it was found, but nothing had been handed in there. "Tory," El May looks at one of his colleagues, "then started talking about the Disabilities Services office." She laughs and says: "I told the people that I had spoken to the manager of Disabilities Services, even though I didn't even know if he existed." Now the whole team laughs. More and more managers came, and in the end they found the implant. "It was completely dirty, in bad condition. But it still worked!" says Fadhel El May.

At the end of the day, Fadhel El May takes the bus home and gets off in the city center. An ambulance howls past. Passers-by cover their ears and El May quickly removes his implant. Sometimes it is an advantage to be able to simply switch off your hearing. "I have to make my peace with this in-between state," he says. One day he may wear an optical cochlear implant. Until then, there will always be situations in which he feels excluded. And also situations in which he is dependent on the help of others. "In the end, what counts is finding the right people in life who are prepared to take a step towards me," he says. And it seems as if he has already found them.

Published on 5 September 2024

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