Computer models of neuronal sound processing in the brain lead to cochlear implant improvements

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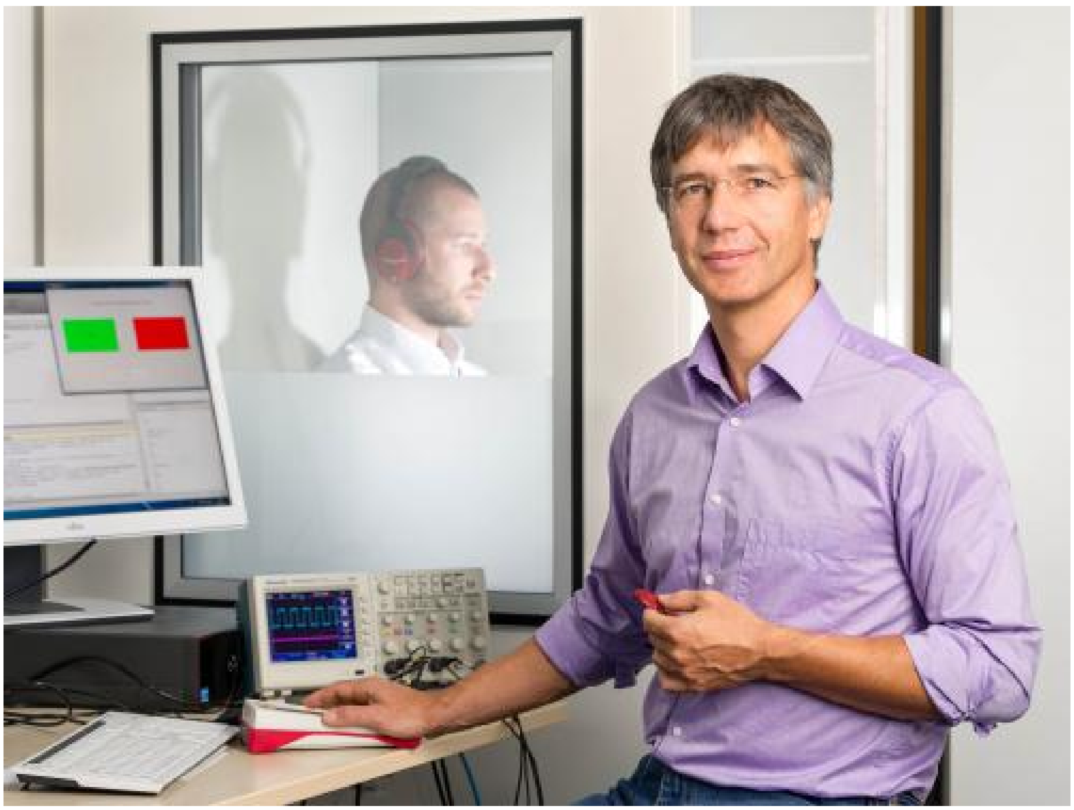


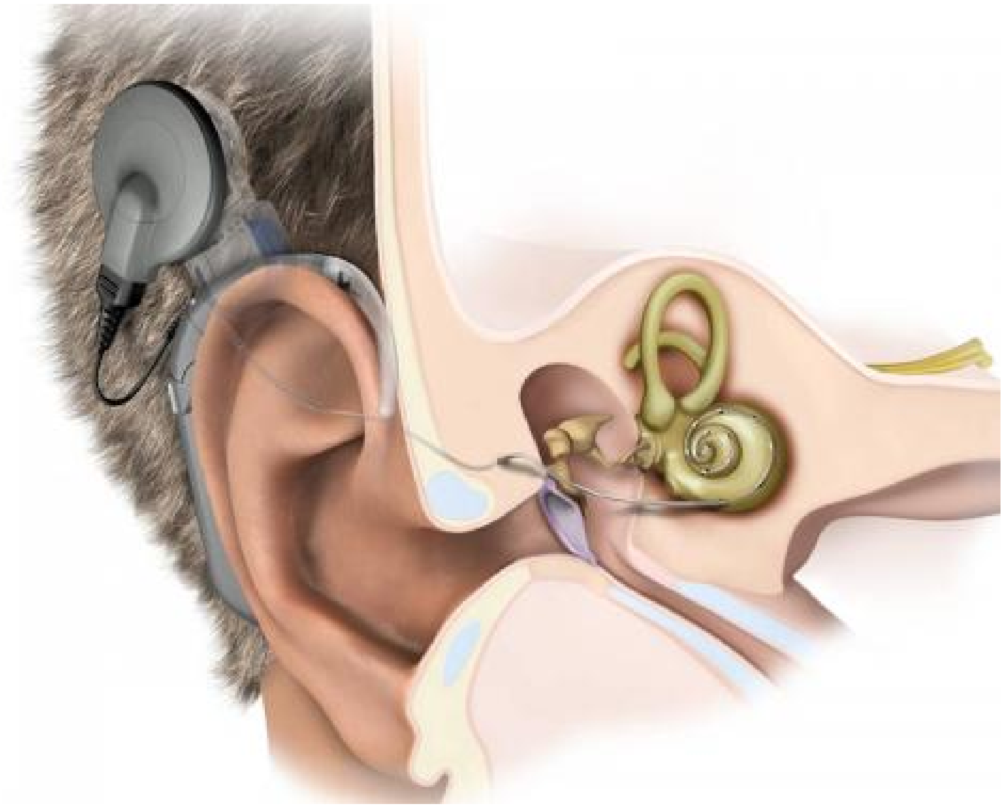
Researchers at the Technische Universitaet Muenchen (TUM) have developed computer models of the neuronal information processing in the brain stem. This model will allow further development of coding strategies to improve future cochlear implants. Credit: Astrid Eckert

Children learning to speak depend on functional hearing. So-called cochlear implants allow deaf people to hear again by stimulating the auditory nerve directly. Researchers at the Technische Universitaet Muenchen (TUM) are working to overcome current limits of the technology. They are investigating the implementation of signals in the auditory nerve and the subsequent neuronal processing in the brain. Using the computer models developed at the TUM manufacturers of cochlear implants improve their devices.

Intact hearing is a prerequisite for learning to speak. This is why children who are born deaf are fitted with so-called cochlear implants as early as possible. Cochlear implants consist of a speech processor and a transmitter coil worn behind the ear, together with the actual implant, an encapsulated microprocessor placed under the skin to directly stimulate the auditory nerve via an electrode with up to 22 contacts.

Adults who have lost their hearing can also benefit from cochlear implants. The devices have advanced to the most successful neuroprostheses. They allow patients to understand the spoken word quite well again. But the limits of the technology are reached when listening to music, for example, or when many people speak at once. Initial improvements are realized by using cochlear implants in both ears.

A further major development leap would ensue if spatial hearing could be restored. Since our ears are located a few centimeters apart, sound waves form a given source generally reach one ear before the other. The difference is only a few millionths of a second, but that is enough for the brain to localize the sound source. Modern microprocessors can react sufficiently fast, but a nerve impulse takes around one hundred times longer. To achieve a perfect interplay, new strategies need to be developed.



The main elements of a cochlear implant are: the hearing aid worn outside, the receiver unit implanted under the skin and the electrode, which stimulates the auditory nerve. Credit: MED-EL GmbH, Innsbruck (Austria)

Modeling the auditory system

The perception of sound information begins in the inner ear. There, hair cells translate the mechanical vibrations into so-called action potentials, the language of nerve cells. Neural circuitry in the brain stem, mesencephalon and diencephalon transmits the signals to the auditory cortex, where around 100 million nerve cells are responsible for creating our perception of sound. Unfortunately, this "coding" is still poorly understood by science.

"Getting implants to operate more precisely will require strategies that are better geared to the information processing of the neuronal circuits in the brain. The prerequisite for this is a better understanding of the auditory system," explains Professor Werner Hemmert, director of the Department for Bio-Inspired Information Processing, at the TUM Institute of Medical Engineering (IMETUM).

Based on physiological measurements of neurons, his working group successfully built a computer model of acoustic coding in the inner ear and the neuronal information processing by the brain stem. This model will allow the researchers to further develop coding strategies and test them in experiments on people with normal hearing, as well as people carrying implants.

The fast track to better hearing aids

For manufacturers of cochlear implants collaborating with the TUM researchers, these models are very beneficial evaluation tools. Preliminary testing at the computer translates into enormous time and cost savings. "Many ideas can now be tested significantly faster. Then only the most promising processes need to be evaluated in cumbersome patient trials," says Werner Hemmert. The new models thus have the potential to significantly reduce development cycles. "In this way, patients will benefit from better devices sooner."

More information: The working group reports on its work in the newly published book, "The Technology of Binaural Listening," which will be presented at the 166th conference of the Acoustical Society of America in San Francisco (2nd – 6th December 2013).

M. Nicoletti, C. Wirtz, W. Hemmert: Modeling Sound Localization with Cochlear Implants, The Technology of Binaural Listening, Springer-Verlag Berlin Heidelberg, 2013

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