High-res images of inner ear could lead to new hearing loss therapies

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(Medical Xpress)—Understanding how hearing works has long been hampered by challenges associated with seeing inside the inner ear, but technology being developed by a team of researchers that includes a biomedical engineer from Texas A&M University is generating some of the most detailed images of the inner ear to date while offering new insight into the mechanics of hearing that could lead to new therapies for hearing loss.

Employing a technique that generates high-resolution, three-dimensional images, Brian Applegate, associate professor in the Department of Biomedical Engineering at Texas A&M, and colleagues from Stanford University are mapping the tissues within the cochlea, the portion of the inner ear responsible for hearing. Their research, which appears in the *Journal of Neurophysiology*, could lead to breakthroughs in understanding of cochlear function, Applegate says.

Although the hearing process hinges on what takes place inside the cochlea, that important area of the inner ear has been traditionally difficult to study, Applegate says. Its small size and the fact that in humans its tissues are encapsulated – and therefore obscured – by dense bone create significant access issues. Researchers, he explains, can't drill into the bone without risking damage to the tissues within or, at the very least, altering the mechanics of the delicate system. These factors, he says, have resulted in a general lack of information about how the cochlea amplifies sound and converts vibrations into nerve impulses. That dearth of functional and structural knowledge about the cochlea is a chief reason hearing loss diagnoses are typically based on circumstantial evidence as opposed to morphological proof, he adds.

New information about how the cochlea works, however, is emerging, thanks to the system developed by Applegate and his colleagues. Capable of rendering detailed images of tissues within an intact cochlea, the system employs a technique known as "optical coherence tomography," or OCT. OCT is similar to ultrasound but generates images with much higher resolution. The images are produced from measurements of the inner ear's structure and the incredibly small vibrations within the cochlea, Applegate says.

Though the technology has been primarily used in animal models to date, it's already resulted in the first vibration measurements from the apex of an unopened mouse cochlea, allowing researchers to image the portion of the cochlea responsible for low frequencies. Since mammalian hearing is similar across species, the model allows the researchers to use the technology on a hearing system similar to the one in humans, Applegate notes.

"We are the first to use this technique on mice in order to image the cochlea," Applegate says. "We're working on making measurements of the movement within the cochlea that have never before been made; we're finding out new things about the mechanics of the inner ear that have not been known."

Among the team's findings is evidence suggesting different areas of the cochlea are responsible for different things, Applegate says. Specifically, gain (the amplification of sound) and narrowing of the frequency band (which enables a person to zero-in a specific sound) take place in distinct areas, he explains. Up until now, these functions have been thought to be closely linked, possibly taking place in the same location, he notes.

"What we've found is that while the outer hair cells inside the cochlea generate gain, some of the nearby supporting cells are largely responsible for the narrowing of the frequency band," Applegate says. "This information contributes to our understanding of the morphology of the inner ear as well as its mechanical functions so that therapies might be developed in the future – but before that can happen, we have to understand what it is that we're trying to fix."

Towards that goal, the OCT technology employed by Applegate generates huge amounts of data about the cochlea. Thousands of measurements are taken from myriad points throughout the cochlea, resulting in gigabytes – and sometimes terabytes – of information that must be processed and interpreted in order to produce images, Applegate explains.

"All of this requires a fair amount of math to generate and interpret the results," Applegate says. "The signal is digitized and passed to something called a Field Programmable Gated Array (FPGA) where initial processing is done before sending it to the CPU. We collect two channels of data but end up only passing one to the CPU because of the data reduction on the FPGA."

Data reduction, Applegate explains, is an important time-saving part of the process made possible by equipment produced by National Instruments, a global leader in providing test, measurement and embedded systems for engineers and scientists. With the aid of the equipment, the data generated from measurements within the cochlea is processed at a significant faster rate, Applegate says.

"We can take a six-hour process and make it happen in a couple of minutes," he says. "We will rely on this data-reducing equipment more and more as we move toward producing a volumetric image that enables us to see an entire sound wave move down the cochlea."

Encouraged by their results, Applegate and his team have developed a prototype device for use on humans. The device, a hand-held instrument, enables a researcher or physician to pass a probe through the ear canal and tympanic membrane in order to shine a laser through a thin membrane located on the cochlea where they can then image the inner ear tissues with the same technology.

"The points of our research is to better understand hearing, to learn more about the actual morphology of the inner ear as well as how it processes vibrations," Applegate says. "We also want to understand how different pathologies affect the ear. We want to know what happens when a person has progressive hearing loss due to loud sounds, traumatic injury or even genetic mutations. We want to see how these things change the soft tissue in the ear."

Provided by Texas A&M University