Brain's 'amplifier' compensates for lost inner ear function

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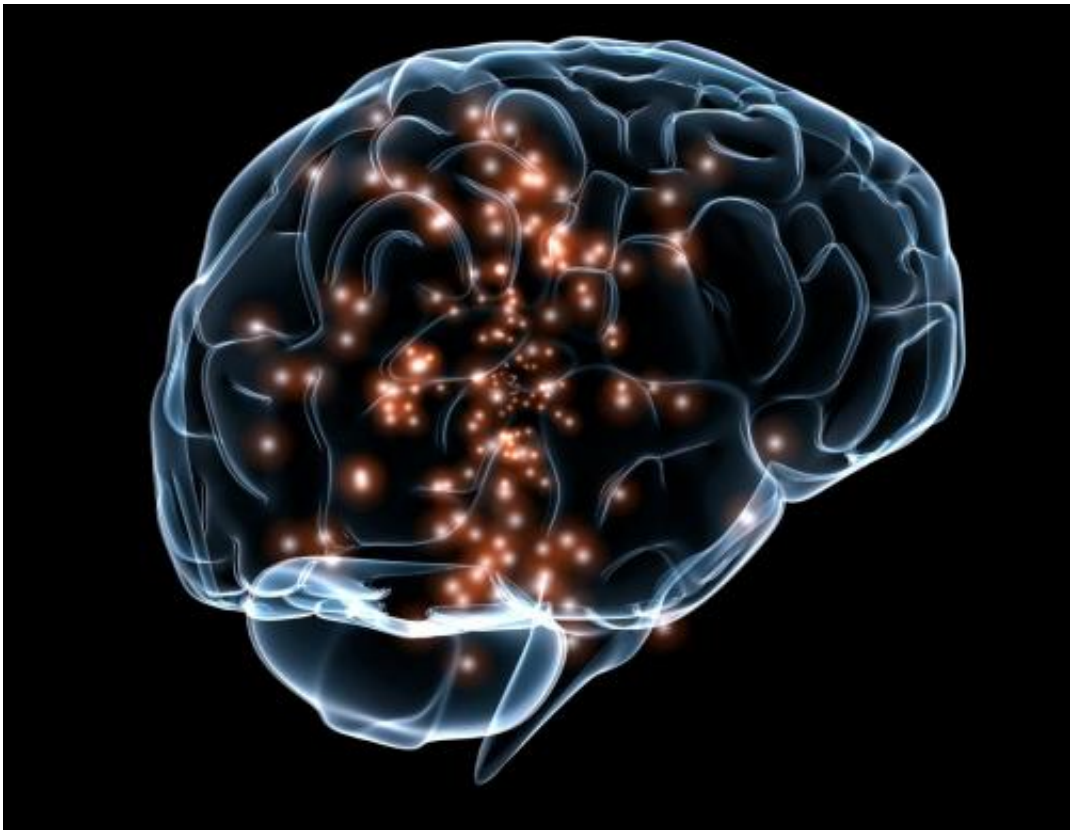

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Researchers from Massachusetts Eye and Ear/Harvard Medical School have described, for the first time, the adult brain's ability to compensate for a near-complete loss of auditory nerve fibers that link the ear to the brain. The findings, published in the current issue of *Neuron*, suggest

that the brain's natural plasticity can compensate for inner ear damage to bring sound detection abilities back within normal limits; however, it does not recover speech intelligibility. This imperfect hearing recovery may explain a common auditory complaint, in which some patients report difficulties understanding speech despite having normal hearing thresholds.

"Our findings suggest that plasticity in the adult brain at higher stages of processing acts as an amplifier—the same way that you'd have an amplifier on a hearing aid," said Daniel B. Polley, Ph.D., Director of the Amelia Peabody Neural Plasticity Laboratory at Massachusetts Eye and Ear and an Associate Professor of Otolaryngology at Harvard Medical School. "It seems that even just 3 percent of the normal complement of inputs is enough for the brain to operate on; however, the compensation is incomplete. There is a cost, and the cost is that the neurons that recover cannot decode complex sounds, such as speech, which are central to our ability to communicate."

The auditory nerve is comprised of thousands of tiny nerve fibers responsible for transmitting sound information to and from the ear and the brain. Recent discoveries have shown that they are the most vulnerable structures in the inner ear, and they naturally die away throughout the human lifespan due to exposure to noise, medications and even simply aging.

Patients who describe difficulties understanding speech despite having normal hearing thresholds recorded with an audiogram have long vexed physicians, and researchers have hypothesized that the loss of nerve fibers contributes to this condition. The *Neuron* authors suggest that the brain's plasticity—its ability to adapt to its environment—also contributes to this clinical presentation.

"Someone with a substantial depletion of auditory nerve fibers would be

sitting across from you and could hear the sound of your voice but would not be able to extract any intelligible information from it, particularly if other people were talking nearby," said Dr. Polley. "The loss of nerve fibers reduces the bandwidth of information that can be transmitted from the inner ear to the brain, which leads to a struggle to process sound information, even if hearing thresholds are normal."

The researchers used chemicals to wipe out nearly all of the nerve fibers charged with processing sound in the inner ears of mice. They then observed normal responses to sound and increased activity in the cortex—the highest stage of processing in the brain—and determined that the cortex is where the "amplifier" resides.

But they also found that there were limits to what could be recovered by the brain's natural plasticity. The researchers found that the increased amplification at higher stages of brain processing could fully recover sensitivity to faint sounds, but that the ability to resolve differences in complex sounds, like speech, did not recover to the same degree.

The findings provoke several important questions that the researchers will address in upcoming studies. The consequences of not having enough amplification are obvious, but the researchers are particularly motivated to explore whether debilitating auditory conditions such as tinnitus or hyperacusis might reflect too much amplification in the system.

"Like feedback from a microphone, having too much gain in the system can push neural circuits toward becoming pathologically hyperactive and hypersensitive," said Dr. Polley. "By establishing the actual cellular components of the brain's amplifier, we hope that one day we might be able to turn the volume knob up and down to find that 'sweet spot' where people can reconnect to the auditory world without hearing phantom ringing or cringing at a loud noise that most people would shrug off as

'tolerable.'"

Provided by Massachusetts Eye and Ear Infirmary