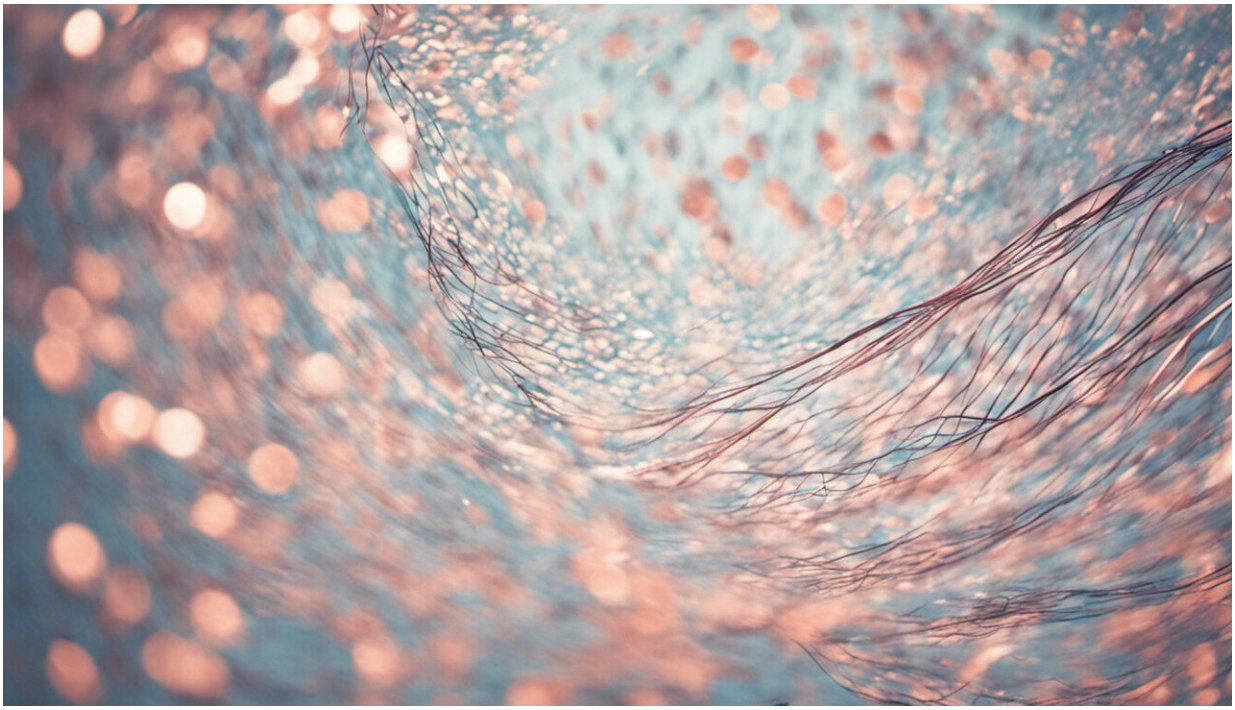
Improving hearing in an increasingly noisy world

May 5 2023, by Anthony King



Credit: AI-generated image (disclaimer)

As knowledge increases about how auditory troubles develop, new technological advances are set to cut through the clamour. Meeting a few friends in a noisy café can mean straining to hear all the conversation. It can be more of a struggle, with age, to make out what a companion is saying in a busy pub or restaurant. Whatever else may improve with

time, a person's hearing does not.

Yet when people complain of poor hearing, they might go for a test only to be told that nothing is wrong.

Missed connections

'The doctor says your audiogram is normal—you don't have a clinical hearing problem,' said Sarah Verhulst, a professor of hearing technology at Ghent University in Belgium.

That doesn't mean the people were imagining their difficulties, however. The hearing trouble may lie elsewhere.

Ageing and loud noise cause wear and tear on the hairs or nerve cells in the inner ear. This damage is what most tests are designed to detect.

But the auditory nerve itself can get impaired, reducing the number and quality of points of connection to brain cells. These junctions are known as synapses.

'This is a new kind of hearing impairment where the synapses attached to hair cells that transmit the sound to the brain are damaged,' said Verhulst.

This synapse harm can be missed in standard hearing tests.

Amplifying sounds using a hearing aid can compensate for fewer hair cells but is less effective in cases of injury to the nerve and its connecting synapses.

Nerve numbers

In healthy hearing, each hair cell has about 15 nerve connections that transmit to the brain, according to Verhulst.

While only one synapse is needed for sound detection, having multiple transmission routes becomes important when trying to tune into specific sounds in an environment with many of them—such as a crowded bar with the music turned up.

With 15 independent channels to transmit the same sound from the inner hair cell to the brain, a person can average this signal and tune out the background acoustic noise. In a noisy environment, someone with fewer synapses will struggle to distinguish sounds.

Auditory difficulty increases with age and can't be solved with hearing aids. As part of the EU-funded RobSpear project, Verhulst developed an alternative in her laboratory in the Belgian city of Ghent.

She measured brain activity using electroencephalograms, or EEGs, to diagnose loss of hearing synapses in people. She then devised algorithms to tweak the sound in a way that is helpful to the remaining nerve connections—for example by enhancing silent periods and sharpening peaks in sound.

'We wanted to stimulate the nerves optimally, but first we needed to understand them,' Verhulst said.

Following the end of RobSpear, which ran for five and a half years into 2022 and was funded through the European Research Council, she hopes her algorithms will be used in all kinds of wearables including hearing aids, headphones and other devices.

The new algorithms could help everyone in environments with lots of background noise, not just people with hearing impairments.

Alarming loss

More than 190 million people in the 53 countries that make up the World Health Organization's European region live with some degree of hearing loss. This figure is projected to rise to over 230 million by 2050.

Modern-day machines, traffic and entertainment all mean that people are more exposed to loud sounds than their ancestors.

'This sort of synapse damage is normal in the new generations who are constantly exposed to noise, such as listening to headphones,' said Verhulst. 'People are going to be hearing impaired at a younger age than for our previous generations.'

Today, those who are deaf or severely hard of hearing can benefit from a cochlear implant. This small device bypasses damaged parts of the ear and stimulates the auditory nerves.

'Cochlear implants are amazing devices for hearing-disabled people,' said Haluk Kulah, a professor of biomedical engineering at the Middle East Technical University in Turkey's capital Ankara.

With existing devices, however, a receiver needs to be attached on the ear close to the auditory nerve.

One major complication is that the external part of the hearing aid is power hungry and users sometimes need to change the battery as often as every day.

There are other disadvantages too. Hearing aids are expensive and vulnerable to damage from exposure to water or physical activity. They can also be lost or create for a stigma for wearers. Furthermore, they aren't very aesthetic and limit users' activities such as swimming.

Promising device

Kulah spent six years working on a device that will avoid all of these troubles by developing a high-performance, fully implantable cochlear implant as part of the EU-funded FLAMENCO project, which ended in 2022. This initiative was also ERC funded.

One of the challenges was how to fit the acoustic sensor and electronics, as well as a reliable power source, all within a space of around five by five millimetres. And other hurdles confronted Kulah.

'The electronic circuit should consume minimal amounts of power and any battery should last for five years or more,' he said.

One idea was to use sound waves to help charge the battery, an approach shown to work in lab tests with hearing-impaired guinea pigs. The result was a cochlear implant with the lowest power consumption recorded, according to Kulah.

More recently, his lab achieved wireless recharging of the device, making it even more convenient for users.

Kulah believes that almost everything possible in a university setting has been done and that it's time for the next phase to begin: commercialisation.

Earlier this year, he received fresh ERC funding to move the device ever closer to patients. His plan is to work with four companies already involved in the production of cochlear implants.

More information:

- RobSpear

- FLAMENCO
- EU-funded health research and innovation

Research in this article was funded via the EU's European Research Council (ERC). The article was originally published in Horizon, the EU Research and Innovation Magazine.