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Turning Down the Phantom Noise Inside the Head

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Sidney Kleinman can't get a good night's sleep. The street can be still, the wind calm and the neighbors peaceful, but the racket and roar in Mr. Kleinman's head can become so loud that it jolts him out of the deepest slumber. There may as well be a block full of car alarms clanging through the night.

"It wakes me up like an alarm clock every hour and a half or so," said Mr. Kleinman, a 69-year-old lawyer in Chicago. "In one ear I hear a sort of electronic pinging, like crickets chirping, and in the other I hear roaring."

The sounds are heard by no one but Mr. Kleinman. They are the result of an odd neurochemical mix-up in the brain, a condition known as tinnitus.

More than 50 million Americans hear these phantom noises from time to time. For most, the sounds are sporadic, and soft enough to be ignored. But for one in five people with tinnitus, the ringing, whistling, pinging or roaring is loud and frequent enough to bring life to a halt.

For years, experts thought the source of tinnitus was in the ears. Usually the odd sounds started after an auditory trauma, like being exposed to noise loud enough to injure the ears, and many sufferers also had some hearing loss in the ear that had ringing or buzzing.

But over the past decade, researchers have been turning their attention to the brain.

Experts now think the illusory sounds are actually the result of faulty signal processing in the brain, very much like the phantom limb pains that can arise after an amputation. In both cases, the brain is trying, and failing, to make sense of the information coming to it from nerves that have been either severed or damaged.

With imaging techniques like functional M.R.I.'s and PET scanning, researchers are pinpointing the regions of the brain where phantom noises originate. The ultimate goal is to find a way to turn off the noise.

Researchers first suspected that tinnitus might have its origin in the brain when treatments that involved cutting the nerve from the ear to the brain failed to stop the ringing in some patients.

Another bit of evidence came from patients who had their auditory nerve removed because it was cancerous.

"They go completely deaf," said Dr. Richard Salvi, a professor at the State University of New York at Buffalo and co-director of its Center for Hearing and Deafness. "And they frequently develop ringing in the deaf ear. The ear is no longer connected to the brain, and yet they perceive sounds like rushing or ringing in the ear. So undoubtedly the tinnitus must be originating in the brain."

But scientists wondered how to prove the hypothesis. Tinnitus can be difficult to study. For some people, the noise turns on and off with no predictability. For others, the ringing or rushing is constant, making it difficult to detect the differences between normal and abnormal brain activity in an individual.

The difficulties inspired some ingenious strategies. In one study, scientists scrutinized patients who had hearing in both ears but experienced phantom sounds in only one. This let the researchers compare brain activity from the two ears.

Using M.R.I.'s, which show changes in brain activity, researchers looked for differences as the subjects of the study listened to sounds in both ears. They expected that since the side with tinnitus was already active most of the time, it would shine less brightly compared with the normal side when sounds were played.

Ultimately, the researchers found that a part of the mid-brain, known as the inferior colliculus, showed the pattern they were looking for.

That doesn't necessarily mean the phantom sounds are generated in the inferior colliculus, said Dr. Jennifer Melcher, an assistant professor at Harvard Medical School and a research scientist at the Massachusetts Eye and Ear Infirmary. "There could be abnormal signals coming from below or above," she said. "We may just be seeing the manifestation there."

In another recent study, researchers scanned the brains of an unusual group of deaf patients with tinnitus who can modulate the ringing or roaring they "hear" by looking left or right.

"When these patients move their eyes from the central position to the side, they can make their tinnitus louder and can change the pitch," Dr. Salvi said. "So we can image the brain when the tinnitus is quiet and when it is loud."

When patients said their tinnitus was loud, the researchers saw activity in a variety of spots, including the brain stem, the mid-brain and the auditory cortex.

"These people have their auditory nerve severed, so the ear is no longer connected to the brain," Dr. Salvi said. "So even though these people will tell you the sound is coming from their ears, it must be originating in the brain."

The study also shows how interconnected the senses are. "The fact that these people can alter the loudness and pitch of their tinnitus with their eye movements illustrates how the brain integrates information from different sensory systems," Dr. Salvi said. "We have to think of the brain as a complicated piece of machinery."

Ultimately, imaging studies may lead to better treatments. "This research is in its infancy," Dr. Salvi said. "But one day we may be able to identify in each patient which area of the brain is behaving abnormally and then select a specific set of drugs targeted for that part of the brain."

Currently, there are no drugs that reduce tinnitus in all patients. "However, there are a few case reports in the literature in which antiseizure medications can reduce tinnitus in patients who have a specific type of tinnitus that appears to originate from seizurelike activity in the temporal lobe, a brain region which processes auditory information," Dr. Salvi said. "As we learn more about the brain's neurotransmitters, their location in the brain and the specific receptors that bind these neurotransmitters, we will be in a better position to evaluate drugs that may be effective in tinnitus therapy."

For now, doctors can offer only therapies designed to help patients turn down the volume. Those treatments must first diminish the perception of the phantom sounds and then reprogram the brain to recognize tinnitus as unimportant.

One remedy is to use sound as a distraction. "The brain detects sensory signals in terms of contrasts rather than absolute magnitude," said Dr. Stephen Nagler, chairman of the board of the American Tinnitus Association and director of the Alliance Tinnitus Hearing Center in Atlanta. "If there is a candle in a pitch-black room, it seems much brighter than a candle in a room with the lights on."

For some patients, a bedside sound generator provides relief, said Dr. William Martin, a professor of otolaryngology at the Oregon Health & Science University. "They come with a wide range of environmental sounds, including wind and ocean sounds," he said. "They all provide nice distracting background that can enable a person to focus on what they want to."

If that doesn't work, doctors can fit a patient with a masking device, a small unit resembling a hearing aid that plays a tone or combination of tones, which can be made loud enough to drown out the phantom sounds.

Often the volume does not need to be set very high because the phantom sound, even if perceived as loud, reaches only a very low level, about six decibels, in 80 percent of patients. Doctors learned this by playing tones to patients and asking them when the volume of the real sound matched that of the tinnitus, Dr. Martin said.

But some patients need extra help. Robert Winston, a district fire chief in Boston, developed such bad tinnitus that he had trouble sleeping and eating.

"I lost 20 pounds," he said. "I was a basket case."

Mr. Winston had had a low, tolerable level of tinnitus for years, until the day he got stuck next to a fire engine with its siren blaring full blast. After that, the tinnitus started to roar.

"Now I had three different sounds that repeat in a loop," he said. "It would start with a sound like a cicada, then it would change to a hissing sound and then it would become high-pitched like the sound of steam coming out of an old radiator pipe."

Mr. Winston is getting help from a technique called habituation therapy. He wears a unit similar to the masking device in his ear. The main difference is that this unit plays a wide range of tones.

"The sound from this device is called white noise; it's more broadband," said Janice Howard, Mr. Winston's therapist and an audiologist with the New England Tinnitus and Hyperacusis Clinic. Over time, she said, the white noise helps the brain learn to ignore the tinnitus. But, she added, patients also need extensive counseling and education to benefit from the device. Improvement can take two years.

"The people I treat are extremely debilitated," Ms. Howard said. "Some are suicidal because they're hearing these sounds 24 hours a day nonstop. They can't sleep. They can't perform at their jobs."

Mr. Winston said: "I've had it a little over a year and it's helped tremendously. But I still have my good days and my bad days."

An experimental approach being investigated at the University of Iowa may also help quiet phantom noises. The new method uses an electrode implanted in the inner ear to stimulate a structure called the cochlea, which turns mechanical vibrations into a signal that the auditory nerve conveys to the brain.

In healthy people, the auditory nerve fires constantly, even when there is no sound, but it has a distinctive firing pattern when sound is absent.

"When you are in a quiet room, your ear is chattering away like crazy," said Dr. Jay Rubinstein, an associate professor of otolaryngology and biomedical engineering at the University of Iowa.

Dr. Rubinstein and his colleagues suspect that when the ear is damaged and the "chatter" stops, the brain interprets the lack of activity as noise. The electrode in their experiment mimics the normal firing pattern of the auditory nerve when there is no sound.

"In theory, this is the code for the sound of silence," Dr. Rubinstein said.

His experimental implant for tinnitus is not the same as the cochlear implant, a device that is not experimental and that is used to help deaf people hear. But cochlear implants for the deaf can also help with tinnitus.

Sidney Kleinman said his tinnitus drops off when his cochlear implant, installed to help him hear, is turned on. "The implant seems to take care of the tinnitus on my right side," he said. "Before I had the implant I had great difficulty working."

Still, when Mr. Kleinman turns the implant off, the pinging and roaring come back, especially at night.

"Once you understand it's not going to kill you, it's not so bad," he said. "I've determined that every day of life is a gift, no matter how bad it gets."