For Hearing Aids, a Lesson From a Fly on the Wall

By ANNE EISENBERG

CARRYING on a conversation in a busy restaurant can be a challenge for anyone who wears a hearing aid. The devices amplify speech, but they amplify the general racket in the room, too.

But a microphone that imitates the remarkably acute hearing of a tiny fly - and gives it a boost with the latest in miniature lasers and signal processing - may one day help solve this problem.

Ronald Miles, a professor of mechanical engineering at the State University of New York at Binghamton, has received a $6.5 million grant from the National Institutes of Health to develop sensing and processing technology for a small, highly sensitive silicon microphone that could be the basis of powerful hearing aids.

The microphone is designed to pick up what a companion across the table is saying while ignoring ambient noise.

The microphone structure is based on the ears of the fly Ormia ochracea. The female of this species uses her fine hearing to pick out the sound of distant crickets, which serve as hosts on which she can deposit larvae. The larvae burrow into the crickets, then eat them as they mature.

Imitating the fly's tympanal structures may yield practical benefits. "This particular fly has solved the problem of hearing and noise," said Lynn Luethke, a program director at the National Institute on Deafness and Other Communication Disorders, the section of the National Institutes of Health sponsoring the Binghamton work. "Dr. Miles is taking that biology and trying to apply it to the mike that would be a component in a hearing aid or, possibly, cochlear implants."

Many people might profit from this research. Some 28 million Americans have hearing loss, Dr. Luethke said. "Only 20 percent of those people who might benefit from hearing aids currently even try them," she said, "and only half of that 20 percent are satisfied."

Dr. Miles' microphone could help change this statistic by preventing some unwanted noise from getting into the ear. "Lots of people that could use hearing aids don't, and for good reason - there's this sense of noise and some distortion of the sound," Dr. Luethke said.

Ormia ochracea deserves a lot of credit for the invention of the microphone, Dr. Miles said. The two membranes on the fly's hearing organ are close together and are mechanically coupled by a hinge-like piece of tissue.

Dr. Miles imitated that hinged design in silicon. "In regular mikes, a membrane that vibrates is clamped all around, like a drumhead," he said. But in his microphone, the membrane works by rocking like a seesaw that is hinged on a central pivot.

"It looks like a teeter-totter, only really small," he said. When acoustic waves come past, the sound pressure drives both sides of the teeter-totter. "If sound comes on both sides at exactly the same time and with the same amplitude," he said, the mechanism doesn't move. But if the sound comes to one side before the other, it moves because the two pressures are inequal.

The design ensures that the diaphragm responds to sound from a specific direction. "What you want is a mike that rejects sound from behind or to the side, responding to sound only from the person talking," he said.

Dr. Miles has fit three of the rocking diaphragms onto a silicon chip about the size of a child's fingertip. Once the membranes are moving, the mechanical motion has to be converted to an electrical signal that can be amplified. Usually this is accomplished through changes in the electrical properties of the diaphragm.

But F. Levent Degertekin, a member of the research team and an assistant professor of mechanical engineering at the Georgia Institute of Technology, has devised optical sensors that he said might allow a more effective microphone design. "We use tiny lasers that can be turned on and off very fast, the same lasers that are usually in optical communications to create zeros and ones," he said.

Like strobe lights taking snapshots, the lasers are used to sample and reconstruct the motion of the membrane. The laser device that detects the position of the membrane, called an interferometer, is easy enough to use in a laboratory, Dr. Degertekin said. The problem comes when it has to be mounted in the confines of a hearing aid. "It's a lot trickier there," he said.

He and colleagues have designed an interferometer small enough to do the job. "We can measure 10 to the minus 14 meters of membrane deflection," Dr. Degertekin said. These are extremely fine measurements, at the size of an atom or smaller. The interferometer uses a laser beam and a light detector to measure the deflection. One part of the beam is reflected from a fixed surface, the other from the surface in motion. As the two beams reach the light detector, sometimes in phase, sometimes out of phase, the change in intensity provides the basis for the measurement.

Douglas L. Jones, a professor of electrical and computer engineering at the University of Illinois at Urbana-Champaign, is doing the signal processing for the device. "We pick up all the signals from the mikes and process them, combining them to get more directionality than you'd get from a single microphone," he said.

Dr. Jones said that while the fly had provided the basis for the project, he hoped that the human component would ultimately help, too.

By integrating optical sensing and signal processing algorithms with the original fly-inspired microphone design, "we are putting a mammalian brain behind a fly's ear," he said. "Combining the two biological systems will hopefully do a better job than either would alone."

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