Postcard from the Future: Robotic ears

Tech Soundings: **Improvements in speech processing and hardware promise to bring the benefits of cochlear implants to more deaf people.**
By Philip E. Ross
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When it was first approved for use in profoundly deaf people, some 15 years ago, the cochlear implant generally worked far better than scientists thought we had any right to expect. The reason was simple: their science was flawed, and cochlear implantation technology helped show why. Now science promises to return the favor, pushing technology to a higher level.

The main problem to be solved is the variability of response to implantation. "We'd like to customize, as eye doctors do for glasses," says Dr. Philip Loizou, director of the Cochlear Implant Laboratory at the University of Texas at Dallas. "I'd like to design a process so that all patients do equally well."

Dr. Loizou here means to compare only patients within similar categories -- children, recently deafened adults, and adults who were deafened in infancy. Young children tend to do best of all, learning to hear almost perfectly, and long-deaf adults do worst of all, barely able to learn to distinguish a ringing doorbell. It is recently deafened adults, however, who show the greatest variability: some can learn to talk confidently on the telephone, whereas others can merely pick up a few auditory clues to fill in the gaps in their lip-reading.

Dr. Loizou attacks the problem from the software side, designing improved speech-processing algorithms to convert sounds into the right kind of electrical signals. Those signals then stimulate surviving auditory hairs -- fibers that hive off from the auditory nerve inside the cochlea, a helical, snail-like structure inside the skull. He consults with all the major players in the field, including the three companies whose products have received FDA approval: Cochlear, an Australian company that has provided three-fourths of the world's 30,000 cochlear implants to date; Advanced Bionics of Sylmar, California; and Med-El, in Austria.

TALK LIKE THIS
Dr. Loizou has studied the number of different channels that implants stimulate. The sentence "The boy did a handstand" sounds like this when stuffed through a single channel. "The dog growled at the neighbors" sounds like this when carried by four channels. "Her husband brought some flowers" sounds like this on eight channels.

Such research matters because although the manufacturers provide as many as 22 electrodes, the patients in fact receive only four to seven channels. "It's like aiming at a piano key but hitting five all at once," says William Heetderks, director of neural prosthesis research at the National Institute of Neurological Disorders and Stroke, part of the National Institutes of Health.

One way to pick out the proper piano key is by getting your finger closer to the target. Today's implants spiral round and round in the cochlea, pressing electrodes up against auditory hairs that, conveniently, are arrayed such that those at one end detect the lowest frequencies and those at the other, the highest ones. Not every patient retains the full complement of hairs, and this may explain part of the variability of response to cochlear implants, Dr. Heetderks says. Another cause of the loss of channels may be electrode interference -- the contacts are, after all, less than a millimeter apart.

Hardware solutions to variable patient responses involve cramming in more functioning channels, typically by putting electrodes closer to the nerve. One method, not yet approved, is to snake electrodes along the inside of the spiral staircase, as it were, rather than the outside, so that the distance from contact to auditory hair is reduced. In an even more radical approach, so far tried only in animals, scientists put the electrodes directly into the auditory nerve.

NO CONE OF SILENCE

"Not only might this be more precise -- hitting one piano key at a time, instead of five -- but the amount of current needed would be 10 to 100 times smaller," says Dr. Heetderks. Power-saving methods such as that could lead to a fully implantable device that didn't require an external power pack and speech-processing unit, which current models partially hide behind the ear. Not only would the cosmetic improvement make a big difference to many users, it would also allow them to swim and shower without having to lower a Cone of Silence.

If the entire thing can't fit inside the skull comfortably, perhaps the speech-processing parts could be carried inconspicuously, say in a shirt pocket, and linked to the implant by Bluetooth wireless -- a trick Dr. Loizou's group has demonstrated to be feasible. The speech processor could even double as a cellular telephone: one ear could be devoted to the phone, the other to the immediate environment.

The idea of implanting both ears is itself a rather daring one, not yet approved for general use. Yet two implants would not only provide redundancy, they would also allow the user to locate the source of the sound. One drawback, of course, is the cost: a cochlear implant costs roughly $30,000 per ear -- half for the device, half for the operation itself.

The most extreme of all strategies, meant to apply only to those few deaf patients who have lost their auditory nerves entirely, is to stimulate directly the cochlear nucleus, deep inside the brain stem. A first-generation device, produced by Cochlear, has recently been approved; the challenge now is to increase the number of channels that can be fitted into the target area.

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