Senses rechanneled

New sensory capabilities can be acquired

by Ann Ewing

See through your ears?

Hear through your eyes?

Both questions sound like a far-out vision.

Yet research now underway indicates man may have this potential. If achievable, it would have obvious implications for the blind and the deaf.

The glimmering dream of acquiring new sensory capabilities is based on laboratory experiments showing that humans may learn new ways of finding out about their environment. If the information can get past the sensory transducer, such as eye's retina or the ear's cochlea, the human brain can process it.

The problem is that humans have learned to process only certain kinds of information through certain specific channels—vibrations in the sound range through the ears, light waves through the eyes, sensations through the fingertips or other skin nerve endings.

But experiments indicate that the nerves carrying these messages to the brain are not specific. With proper training the nerves can be taught to translate one kind of information into another. One outstanding example of acquiring new sensory capabilites is the blind person who learns to read through his fingertips by converting a certain pattern of raised dots to letters and words.

Anyone who thinks about the implications of this is likely to conclude that there should be better, or faster, ways to transmit this information to the brain than raised dots, lipreading or records.

Research by Dr. Wilson P. Tanner Jr., director of the sensory intelligence laboratory at the University of Michigan, and others, may be laying the foundation for a much more efficient method, relying on the ability of the ears to learn to see. The applications will not come, however, until scientists there and at other institutions around the country have learned how and under what conditions humans can be taught new sensory capabilities through experience.

Dr. Tanner, for instance, reasons that when a baby learns new information about his environment, such as how to tell his mother from his father, he makes not tens, but hundreds or even thousands of attempts before achieving a positive identification at every try. Dr. Tanner therefore believes that scientists testing the ability of adult humans to learn new information through their ears should run not just tens, but hundreds and very likely thousands of trials.

One example Dr. Tanner has used to make his point is the hypothetical one of a baby born with mixed-up nerves—his optic nerve hooked up to the cochlea and his acoustic nerve attached to the retina. Such a child might hear and see equally as well as one born with nerves routed in the usual way. As he grew day by day and month by month, the baby would learn to hear and see because he would have built up by experience knowledge of the world around him, as a normal child does.

In other words, information about the environment would be transmitted to the brain in a form, based on long experience, that the cortex can handle. The acoustic and optic nerves are not tailor-made to particular tasks or able to transmit only specific information. They merely carry signals to the brain's cortex where the signals are interpreted as light or sound.

Despite the seeming fact that vision and hearing are limited to definite ranges, humans actually have a much broader potential for passing information to the brain. They have untapped sensory capabilities that can be trained, but exactly how far such learning can be pushed is not now known. The subject is being investigated at several laboratories.

Basis of the investigation is the highly mathematical theory of signal detectability. Dr. Tanner and co-workers at the University of Michigan's electronic defense group participated in some of the original work. They were interested in building signal detection devices such as radar and sonar. To do this, it is necessary to have a theory on which to base the measurements, ask the appropriate questions and build the appropriate equipment.

The result was a mathematical description of the ideal observer, based on the assumption that it is possible to build a machine that has the desired ideal characteristics. This does not mean a machine making no errors, but one that makes the best possible use of available information.

The theory of signal detection proved more than adequate for the engineers who continued to build, test and improve radar and other detection equipment according to its specifications. However, Dr. Tanner, who has a Ph.D. in psychology, wondered if the same mathematical theory could be used to evaluate the reactions of a human observer.

The concept of an ideal observer provides an absolute standard of reference by which human performance can be evaluated. The rub is that the adjective "ideal" refers to the best possible performance in detecting signals under specified conditions. The reason scientists study ideal observers when they are actually interested in real observers is to establish a standard of comparison for human detection.

If a change in the stimulus, a sound wave for instance, makes the signal harder to detect for the ideal observer, then the same change would be expected to make the signal harder to detect for a human observer.

One result of applying detection theory to humans is that it is possible to separate the detectability of the signal, which is a sensory process, from the decision criterion applied by the subject, which is a response or motivational process.

Dr. Tanner, the person most responsible for bringing signal detection theory into psychophysics, believes that humans have a central coding process by which information from the environment is transmitted to the brain. How this information is coded is influenced by a person's experience.

At a recent National Academy of Sciences meeting in Ann Arbor, Mich., Dr. Tanner reported his most recent experiments showing that sensory capabilities can be acquired through experience. His experiments involved discriminating among sound signals containing physical differences not encountered in everyday living.

In each of three experiments, the subject chose from among four alternatives. One experiment involved sound signals differing only in the position in time in which they were heard; the second involved signals differing both in time and frequency, and the third added a visual input randomly half the time to the second experiment.

Chance behavior was recorded for several thousand trials, in one case for 6,000. However, with added incentive —money—for correct identification and with knowledge of whether the previous response to the signal was correct or not, performance improved until there was from 85 to 95 percent accuracy.

The experiments show that sensory capabilities can be acquired, since the subjects learned to discriminate not on the basis of their previous knowledge but on the basis of new information learned through trial and error during the many thousands of tests.

The implications are that, if a way can be worked out to present as inputs to the ear some version of signals that would normally be seen by the eye, then blind persons would be able, in effect, to see through their ears. Conversely, if some method of coding usually auditory signals in the form of light could be devised, then the deaf would be able to hear through their eyes.

This is for the future, however. Today's experiments are aimed only at obtaining the basic information needed before building one piece of equipment.

Preliminary studies are already underway at some laboratories to determine other possible applications of signal detection theory. These include animal psychophysics, physiology of sensory reception, reaction time, vigilance, attention, subliminal perception and recognition memory.

Many of the results of these studies have contradicted 100 years of physiological testing in the field of human hearing and, by implication, how humans react to their environment. They had, and are still having, an impressive impact on the scientific community, despite the hard sledding encountered when Dr. Tanner and such colleagues as Dr. David M. Green of the University of California at San Diego, Dr. Theodore G. Birdsall, also of the University of Michigan, and Dr. John A. Swets, vice president of Bolt, Beranek and Newman, Cambridge, Mass., reported their early results.

Now there are converts just as enthusiastic as Dr. Tanner and his assistant director, Dr. Dana Main. Among these are Dr. William J. McGill of the University of California at San Diego, who is studying how hearing differs when sound is heard with two ears and only with one; Dr. Lloyd Jeffress, who is building electrical analogues of the auditory system; Dr. James P. Egan of Indiana University; Dr. Charles Watson of the Central Institute of the Deaf; Dr. Frank Clarke of Stanford Research Institute; Dr. J. C. R. Licklider of Massachusetts Institute of Technology and IBM Corporation; Dr. C. D. Creelman of the University of Toronto, and Dr. Israel Goldiamond of the Institute for Behavioral Research, to name a few.

Until 1954, there was only a handful of scientific reports dealing with the general theory of signal detectability, and very few even at the end of that decade. Now there are some 300 papers on the subject of signal detection in psychology, plus uncounted others in engineering and mathematics.