Watching a Brain-Watcher Work

What he really wants to find out is how his own brain works.

Derek Fender, professor of biology and applied science, concentrates most of his scientific energies these days on learning how brain waves are propagated. There are plenty of possible applications for his research—learning how to spot brain tumors, diagnose brain injuries, identify sources of epileptic seizures, or how to build a foolproof lie detector, for example.

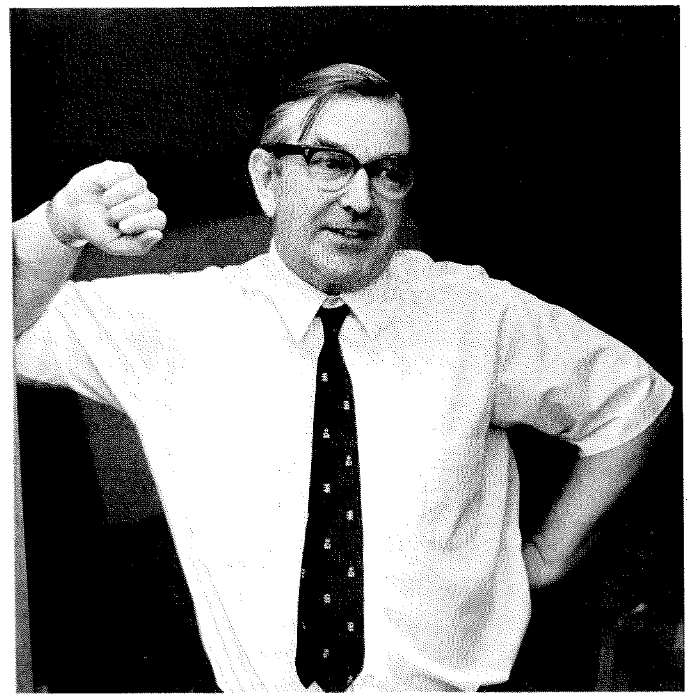
But though he's glad his experiments may benefit others, such practical applications really aren't Fender's main interest. His real reason for studying the brains of monkeys and other animals, including humans, is essentially egotistical. The fact is, he doesn't much care how monkeys' brains work. He isn't even primarily interested in how man's brain in general works. What he really wants to find out is how his own brain works. And he's honest enough to admit it.

He can't point to any single experience that prompted his motivation; rather, he thinks it has grown over his professional lifetime. But accidental or not, the historical process whereby Fender arrived at his brain wave experiments is just as intriguing as the experiments themselves.

On July 15, 1939, Derek Fender was awarded a bachelor of science degree in physical sciences from Reading University in England. Twenty-four hours later, as part of the first draft call in British history, he was in a truck headed for the Royal Berkshire Regiment—the first stop on a six-month tour of duty in His Majesty's Army. Five weeks after that Great Britain entered World War II, and the young physicist's six-month tour stretched into eight years.

A few months after the war broke out, the massive push began at Whitehall—the British equivalent of the Pentagon—to develop radar, and Fender, like practically every other qualified physicist or engineer in the country, was put to work on the project. His main area of concentration was the development of control systems for both the antenna and the antiaircraft guns, and it was here that he first became aware of the human engineering aspects of a man-machine system.

For example, getting the antiaircraft gun to fire at a point where the aircraft would be in, say, 30 seconds (the time it would take the projectile to get there) involved a neat exercise in three-dimensional mathematics —even without taking into account the human element. But in fact it was not enough to know aircraft range, bearing, altitude, and speed, for a major determining factor turned out to be the enemy pilot himself.



Derek Fender, professor of biology and applied science, began his career studying automated systems; then he turned to man-machine systems. Now he does research into the nature of the cognitive processes in the brain of man.

Some flew zigzag patterns, others swooped and dove, others flew yet different patterns. Fender and his crew eventually discovered there were certain flight characteristics that helped to classify a given aircraft according to one flight pattern or another, and these in turn could be used to narrow down the number of probable future target positions.

Another human engineering problem cropped up when it was found that the British gunners couldn't adjust the positions of their guns fast enough to keep up with the "predictor"—an early version of an analog computer, which translated enemy aircraft flight behavior picked up on radar into commands to the gunner. This human time lag in the system meant that the guns could not track with the enemy planes. Fender and his team attacked the problem informally at first, but their effort soon grew into a major undertaking known as the Human Operator Project.

This was Fender's first in-depth experience with human engineering. He and his team dealt with the problem by considering the human operator as a "black box," with certain input and output characteristics just like any other component of a system. This necessarily entailed a lot of research in human perception and response. As a result of the project, enough was eventually learned about operator performance characteristics so that appropriate allowances could be made in the commands issued by the computer.

His wartime experience with the human operator problem in antiaircraft systems made Fender uniquely qualified in the newly discovered field of human engineering, and in 1947 he became a lecturer in the subject at the Royal Military College of Science at Shrivenham—an institution roughly equivalent to military postgraduate schools in the U.S. The British Army, being very much aware by now of the importance of human engineering in an age of mechanized warfare, was the first branch of the services to teach the subject formally, and during the years immediately following the war Fender taught classes of military officers from all over the Commonwealth.

While a lecturer at Shrivenham, Fender took his second BSc (Special)—which is much the same as the American master's degree. But in the highly structured English academic system he still found his horizons severely limited by the lack of a PhD, despite his qualifications in his field. So, in 1953 the Fender family, which now included a wife and two children, moved to Reading, and with the help of R. W. Ditchburn, head of the physics department, Fender got a junior faculty job at Reading University. He managed at the same time to enroll in the PhD program in physics there. Fender reckons that in addition to his doctoral research at the time, he had 12 to 15 hours of classes to teach—plus the donkey work of labs and correcting papers—and it made a full load by any standard.

Despite this horrendous schedule, he had made sanguine plans: In the course of the three-year program, he intended to do one book in the first year, another book in the second year, and his thesis in the third year. As things turned out, everything was written in the final year.

After that life smoothed out considerably. Fender was immediately promoted from "demonstrator" (something like a teaching assistant) to "lecturer grade I"—the equivalent of a full professor in an American university.

Fender came to Caltech first as a senior research fellow in 1961, and the year after that he was appointed professor of biology and applied science. Some of his research since has involved him in a joint project at the Institute of Visual Sciences in San Francisco, where he collaborated with Dietrich Lehmann on problems in clinical electroencephalography. The problems he encountered on this project in the analysis of conventional EEG records motivated him to refine the design of his own 49-electrode helmet.

During this project, Fender and his colleague discovered that the best subjects for their brain wave study were waitresses. College students were too inquisitive; their heads were full of what Fender calls "flat-fast" brain waves, characteristic of problem-solving activity. Other sorts of people (Fender refuses to identify them) simply went to sleep, and all the electroencephalograph could pick up was the long, smooth brain wave characteristic of an idling or sleeping brain.

But waitresses were just right. They were bright, so they didn't fall asleep. They were industrious enough to concentrate on the light-flash stimulus they were being paid to watch. And they weren't too nosy about what was going on or too preoccupied with some other problem, so they didn't show much flat-fast brain wave activity.

Fender doesn't foresee any fundamental change in the over-all direction of his research, though he does note a tendency on his own part to be less involved with the details of every research project that he advises or manages. But anybody who thinks Derek Fender is getting away from research should watch him do his experiments. One of those futuristic-looking electrode helmets used to gather brain wave data fits nobody else's head but his, and it's the most frequently used helmet of all.