nature neuroscience

Forensic neuroscience on trial

An interesting court case is unfolding in Iowa, where Terry Harrington, convicted for the 1977 murder of a retired police officer, is appealing his conviction. His defense is based in part on a 'brainwave' test, which according to its proponents can establish the presence or absence of incriminating memories in the brain of a suspect using electroencephalography (EEG). Harrington took the test with negative results, and his attorneys are seeking to have this admitted as evidence in a new hearing. A judge's ruling on admissibility is expected shortly, and is likely to attract considerable media attention; TV cameras have been present throughout the hearing.

The brainwave test has yet to be accepted by any court, but the underlying scientific principle is well established. The test is based on the widely studied P300 response, an EEG signal that is evoked by 'oddball' stimuli with a latency of about 300 milliseconds. In a typical study, a subject is presented with a series of visual stimuli and asked to categorize them in some way. If one category is rare relative to the other, it evokes a P300 response, whose magnitude increases as the likelihood of the 'oddball' stimulus decreases. In 1988, Emanuel Donchin and his student Lawrence Farwell demonstrated that a P300 signal is evoked independent of the subject's behavioral response, by any stimulus that is in some way distinctive for that subject. The authors, whose research was funded by the CIA, proposed that P300 could be used as a forensic test, analogous to the 'guilty knowledge test' that is sometimes used in polygraphy. The suspect is presented with a series of stimuli, a few of which are chosen to be distinctive only to a person with inside knowledge of the crime. A P300 signal in response to these probe stimuli would be evidence of such knowledge.

The test on Harrington was performed by Farwell, who is now seeking to commercialize the forensic use of EEG. But some experts are unconvinced by Farwell's claims, including his former mentor Donchin, who was a witness for the opposing side. Donchin accepts that the test can work in a controlled laboratory setting, but he believes that it has not been adequately validated under real-world conditions. J. Peter Rosenfeld, an EEG expert at Northwestern University, who was also ready to testify but was not called, agrees, describing Farwell's claims as "nonsense". In contrast, William Iacono of the University of Minnesota, who testified in favor of Farwell, argues that the method is scientifically valid and that a jury should be given the opportunity to weigh the evidence it produces.

The situation has clear parallels to the debate over the validity of polygraph tests, which has been raging for many years. Polygraphs, which measure autonomic responses such as skin conductance and blood pressure, are widely used by law enforcement and intelligence services, and are believed by at least some scientists to provide reliable results if properly used. However, they have not yet been widely accepted by the US courts, and although defense lawyers often attempt to introduce them in evidence, they seldom succeed. This situation dates from 1923, when the US Supreme Court ruled that an early form of the polygraph test was inadmissible as evidence, on the grounds that it was not 'generally accepted' by the scientific community. The court's ruling had broad implications for the admission of scientific testimony in court: 'general acceptance' is a very stringent standard, given that controversy is inherent to the process of scientific discovery.

Although juries need to be protected from confusion by junk science, it is also their job to evaluate controversial evidence. In an important 1993 case, *Daubert v. Merrell Dow Pharmaceuticals*, the Supreme Court ruled that the 'general acceptance' criterion was too strict, and it gave judges wider discretion to admit or exclude scientific testimony. It provided some guidelines for recognizing scientifically valid evidence. General acceptance by the scientific community, while still relevant, is no longer a necessary precondition, and additional considerations include: has the theory been tested, has it been peer reviewed, what is the error rate, and are there accepted standards for its practical application? Importantly, scientific evidence need not be 100% reliable; anything that can alter the likelihood of material facts is potentially admissible, leaving it up to juries to decide how much weight to place on the evidence.

In principle, there seems no reason why an EEG-based test could not meet these legal requirements. Nobody disputes that EEG can reflect brain states, including the presence of memory traces, and measuring brain activity is inherently more direct than measuring secondary effects such as skin conductance. The short latency of the EEG response gives less time for it to be suppressed, suggesting that it may be harder to cheat than a conventional polygraph test. It is also more versatile; Rosenfeld, for instance, is working to detect deception based on the spatial distribution of the EEG signal, which he believes may eventually form the basis for a reliable lie detector.

Whatever the Iowa court may decide, the forensic application of EEG is still in a very early phase of development. Even if admitted in evidence, it would appear vulnerable to many of the challenges that are routinely raised against polygraph tests. For instance, real criminals, or innocent suspects fearful of being wrongfully convicted, may give different signals from volunteer subjects. In a real crime situation, perpetrators may not encode the incidental memories that underlie the guilty knowledge test, particularly if they are intoxicated. Moreover, as Donchin points out, the selection of test stimuli is still an art rather than a science, and without an objective set of criteria, statistical generalization is difficult.

These questions can only be resolved by extensive field-testing. This seems desirable; although EEG testing may raise the specter of 'Big Brother' in the public imagination, it is in reality just another tool for determining the facts, no different in principle from handwriting, fiber or DNA evidence. Moreover, its use by prosecutors, at least in the US, would be governed by the constitutional protection against self-incrimination, and its main application in the courts would probably be to argue for innocence rather than guilt.