

Brain mapping & Printing



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ABSTRACT

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Physical injury to the brain such as concussion disrupts normal flow of electrical impulses in the brain tissue. Similarly toxic injury, seizure disorder, Alzheimer's disease, anoxia and brain infection (chronic lyme encephalitis) after brainwave activity. ADD, OCD, anxiety, depression and learning disability have distinct brainwave "signatures".

EEG or electroencephalogram is a recording of brainwave activity. QEEG (Quantitative EEG), popularly known as brain mapping, refers to a comprehensive analysis of brainwave frequency bandwidths that makeup the raw EEG. QEEG is recorded the same way as the EEG, but the data acquired in the recording are used to create topographic color-coded maps that show electrical activity of the cerebral cortex.

While other brain mapping techniques (CT, MRI, PET, SPECT) Measure such properties as cerebral blood flow, metabolism or structural integrity, QEEG measures electrical activity of the brain. It provides complex analysis of such brainwave characteristics as symmetry, phase, coherence, amplitude, power and dominant frequency. In fact, subtle disruptions of electrical connectivity and flow in the brain sometimes may be the only or the early signs of a problem.

INTRODUCTION:

Scientists have been trying to understand the inner workings of the brain for hundreds of years. The brain has been studied by many methods, and attempts to map brain function date back to the practice of Phrenology in the 18th and 19th centuries. Phrenology was based on the erroneous assumption that a person's character and mental competence could be determined by the size, shape, and proportions of the skull. Frances Joseph Gall originated phrenology by designating 26 areas of the skull associated with different mental functions.

Brain function had been studied before this, but Phrenological maps were one of the earliest attempts to spatially represent brain functions. Since that time, many techniques have been developed that directly, or indirectly, measure neural activity of the brain.

It has been known for many years that activation of nervous tissue causes increased blood flow to the activated area. In 1876, Angelo Mosso, an Italian physician and physiologist, published the results of his study of the cerebral blood flow (CBF) in a woman with part of her skull removed secondary to infection with Syphilis. He placed a Plethysmograph directly on the dura mater and recorded changes in the brain volume resulting from changes in blood flow to the cerebrum.

Most studied several other patients with open skulls, observing increases in CBF when they were asked to solve mathematical problems (Cognitive function), and when they responded to emotional stimuli. He also studied the CBF during physical exertion, sleep, arousal from sleep, and during epileptic seizures. Increased CBF rate and volume to an activated area of the cerebral cortex is referred to as the hemodynamic response. From this crude beginning, blood flow to the cerebral cortex and its relationship to cortical activation has been continuously studied.

In the late 19th century, Paul Broca began using multichannel cerebral thermometry to map brain function using localized changes in temperature. He measured scalp temperature in various regions during the performance of specific tasks or after administration of specific stimuli.

COMPARISON WITH OTHER TECHNOLOGIES:

Conventional fingerprinting and DNA match physical evidence from a crime scene with evidence on the person of the perpetrator. Similarly, Brain fingerprinting matches informational evidence from the crime scene with evidence stored in the brain. Fingerprints and DNA are available in only 1 percent of crimes. The brain is always there, planning, executing and recording the Suspects actions. Brain fingerprinting has nothing to do with lie detection. Rather, it is a specific way to determine if

someone has committed a specific crime or other act. As with DNA and fingerprints, the results are the same whether the person has lied or told the truth at any time. It is a controversial proposed investigative technique that measures recognition of similar stimuli by measuring electrical brain wave responses to words, phrases, or pictures that are presented on a computer screen. Brain fingerprinting was invented by Lawrence Farwell. The theory is that Suspects reaction to the details of an event or activity will reflect if the suspect had prior knowledge of the event or activity. This test uses what Farwell calls the MERMER: Memory and Encoding Related Multifaceted Electroencephalographic Response.response to detect familiarity reaction. One of the applications is lie-detection.

DEFINITION:

Brain fingerprinting is designed to determine whether an individual recognizes specific information related to an event or activity by measuring electrical brain wave responses to words, phrases or pictures presented on a computer screen. The technique can be applied only in situations where investigators have a sufficient amount of specific information about an event or activity that would be known only to the perpetrator and investigator. In this respect, Brain fingerprinting is considered TYPE OF Guilty knowledge.

ADMISSIBILITY OF BRAIN FINGERPRINTING IN COURT:

The admissibility of brain fingerprinting in court has not yet been established. The following well established features of Brain fingerprinting however, will be relevant when the question of admissibility is tested in court.

- 1) Brain fingerprinting has been thoroughly and scientifically tested.
- 2) The theory and application of Brain fingerprinting have been subject to peer review and publications.
- 3) The rate of error is extremely low-virtually non-existent and clear standards governing scientific techniques of operation of the technology have gained general acceptance the relevant scientific community.
- 4) Brain fingerprinting is non-invasive and non-testimonial

TECHNIQUE:

The person to be tested wears a special headband with electronic sensors that measure the electroencephalography from several locations on the scalp. In order to calibrate the brain fingerprinting system, the testee is presented with a series of irrelevant stimuli, words, and pictures, and a series of relevant stimuli, words and pictures. The test subjects brain response to these two different types of stimuli allow the tester to determine if the measured brain response to test stimuli, called probes, are more similar to the relevant or irrelevant responses. The technique uses the well known fact that an electrical signal known as P300 is emitted from an individual's brain approximately 300 milliseconds after it is confronted with a stimulus of special significance, e.g. a rare vs. a common stimulus or a stimulus the probe and is asked to count.

The novel interpretation in brain fingerprinting is to look for P300 as response to stimuli related to the crime in question e.g., a murder weapon or a victims face. Because it is based on EEG signals, the system does not require the testee to issue verbal responses to questions or stimuli. Brain fingerprinting uses cognitive brain responses; brain fingerprinting does not depend on the emotions of the subject, nor is it affected by emotional responses.

Brain fingerprinting is fundamentally different from the polygraph (lie-detector), which measures emotion based physiological signals such as heart rate, sweating, and blood pressure. Also, unlike polygraph testing, it does not attempt to determine whether or not the subject is lying or telling the truth. EEG is the measurement of electrical activity produced by the brain as recorded from electrodes placed on the scalp. Just as the activity in a computer can be understood on multiple levels, from the electrical activity of the brain be described on relatively small to relatively large scales.

At one end are action potentials in a single axon or currents within a single dendrite of a single neuron, and at the other end is the activity measured by the EEG which aggregates the electric voltage fields from millions of neurons. So called scalp EEG is collected from tens to hundreds of electrodes positioned on different locations at the surface of the head. EEG signals (in the range of mv)

are amplified and digitalized for later processing. The data measured by the scalp EEG are used for clinical and research purposes. Scalp EEG activity oscillates at multiple frequencies having different characteristic spatial distributions associated with different states of brain functioning such as waking and sleeping. These oscillations represent synchronized activity over a network of neurons.

The neuronal networks underlying some of these oscillations are understood (such as the thalamocortical resonance underlying sleep spindles) while many others are not (the system that generates the Posterior basic rhythm)

ROLE IN CRIMINAL PROCEEDINGS:

The application of Brain fingerprinting testing in a criminal case involves four phases: Investigation, interview, scientific testing and adjudication. Of these four phases, only the third one is in the domain of science. The first phase is undertaken by a skilled investigator, the second by an interviewer who may be an investigator or a scientist, the third by a scientist, and the fourth by a judge and jury. In legal proceedings, the scope of the science of Brain fingerprinting and all other science is limited.

The role of Brain fingerprinting is to take the output of investigations and interviews regarding what information is relevant, to make a scientific determination regarding the presence or absence of that information in a specific brain, and thus to provide the judge and jury with evidence to aid in their determination of guilt or innocence of a suspect.

USES AND APPLICATIONS:

The various applications are as follows:

- 1) Test for several forms of employment, especially in dealing with sensitive military and foreign intelligence screening.
- 2) Individuals who were "information absent & present".
- 3) A group of 17 FBI agents and 4 non-agents were exposed to stimuli.
- 4) To detect symptoms of Alzheimer's disease, mental depression and other forms of dementia including neurological disorders.
- 5) Criminal cases
- 6) Counter-terrorism
- 7) Security testing.

BRAIN MAPPING TECHNOLOGY AND METHODS

Scientists use many methods to study the brain's structure and function. They take pictures of healthy brains and compare them to diseased brains. In addition, they examine brains taken from humans, primates and small mammals and try to understand how invertebrates' smaller nervous systems work. On a microscopic level, they also examine neurons.

Here are some tools used in brain mapping. These techniques take images of the brain:

Computer axial tomography (CAT) scan X-rays the brain from many angles and show structural abnormalities. Structural magnetic resonance imaging takes advantage of water in the brain to create images with better resolution than a CAT scan.

Diffusion tensor-MRI (DTI) images "tracts" of neurons that connect brain regions by following water movement in the brain.

These techniques examine brain activity:

Electroencephalography (EEG) indicates electrically active locations in the brain using detectors implanted in the brain or worn on a cap.

Positron emission tomography (PET) takes images of radioactive markers in the brain.

Functional MRI (fMRI) shows images of brain activity while subjects work on various tasks. Pharmacological functional MRI (phMRI) shows brain activity as drugs are administered.

Transcranial magnetic stimulation (TMS) noninvasively stimulates parts of the brain to trigger certain behaviors. New methods allow researchers to see all the connections between neurons in an intact brain. This branch of study is called connectomics.

The "wiring diagram" of a brain is called a connectome [source: Lichtman]. "Until recently, we've had no hope of getting these wiring diagrams," says Jeff Lichtman, a Harvard biologist who led the group that developed some of the new techniques. "We could see individual cells, but never all of them at once."

LIMITATIONS OF BRAIN FINGERPRINTING

Brain fingerprinting detects information-processing brain responses that reveal what information is stored in the subject's brain. It does not detect how that information got there. This fact has implications for how and when the technique can be applied. In a case where a suspect claims not to have been at the crime scene and has no legitimate reason for knowing the details of the crime, and investigators have information that has not been released to the public, brain fingerprinting can determine objectively whether or not the subject possesses that information. In such a case, brain fingerprinting could provide useful evidence.

If, however, the suspect knows everything that the investigators know about the crime for some legitimate reason, then the test cannot be applied. There are several circumstances in which this may be the case. If a suspect acknowledges being at the scene of the crime, but claims to be a witness and not a perpetrator, then the fact that he knows details about the crime would not be incriminating. There would be no reason to conduct a test, because the resulting "information present" response would simply show that the suspect knew the details about the crime – knowledge which he already admits and which he gained at the crime scene whether he was a witness or a perpetrator.

Another case where brain fingerprinting is not applicable would be one wherein a suspect and an alleged victim – say, of an alleged sexual assault – agree on the details of what was said and done, but disagree on the intent of the parties. Brain fingerprinting detects only information, and not intent. The fact that the suspect knows the uncontested facts of the circumstance does not tell us which party's version of the intent is correct.

In a case where the suspect knows everything that the investigators know because he has been exposed to all available information in a previous trial, there is no available information with which to construct probe stimuli, so a test cannot be conducted. Even in a case where the suspect knows many of the details about the crime, however, it is sometimes possible to discover salient information that the perpetrator must have encountered in the course of committing the crime, but the suspect claims not to know and would not know if he were innocent.

This was the case with Terry Harrington (*Harrington v. State* 2001). By examining reports, interviewing witnesses, and visiting the crime scene and surrounding areas, Dr. Farwell was able to discover salient features of the crime that Harrington had never been exposed to at his previous trials. The brain fingerprinting test showed that the record in Harrington's brain did not contain these salient features of the crime, but only the details about the crime that he had learned after the fact.

Another situation where brain fingerprinting is not applicable is one where the authorities have no information about what crime may have taken place. For example, an individual may disappear under circumstances where a specific suspect had a strong motive to murder the individual.

Without any evidence, authorities do not know whether a murder took place, or the individual decided to take a trip and tell no one, or some other criminal or non-criminal event happened. If there is no known information on which a suspect could be tested, a brain fingerprinting test cannot be structured.

Similarly, brain fingerprinting is not applicable for general screening, for example, in general pre-employment or employee screening wherein any number of undesirable activities or intentions may be relevant. If the investigators have no idea what crime or undesirable act the individual may have committed, there is no way to structure appropriate stimuli to detect the telltale knowledge that would result from committing the crime.

Brain fingerprinting can, however, be used for specific screening or focused screening, when investigators have some idea what they are looking for. Brain fingerprinting does not detect lies.

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It simply detects information. No questions are asked or answered during a brain fingerprinting test.

The subject neither lies nor tells the truth during a brain fingerprinting test, and the outcome of the test is unaffected by whether he has lied or told the truth at any other time. The outcome of "information present" or "information absent" depends on whether the relevant information is stored in the brain, and not on what the subject says about it (Farwell 1994, PBS 2004, Farwell 2012).

Brain fingerprinting does not determine whether a suspect is guilty or innocent of a crime. This is a legal determination to be made by a judge and jury, not a scientific determination to be made by a computer or a scientist (Farwell 1994, PBS 2004, Farwell 2012).

Brain fingerprinting can provide scientific evidence that the judge and jury can weigh along with the other evidence in reaching their decisions regarding the crime. To remain within the realm of scientific testimony, however, a brain fingerprinting expert witness must testify only regarding the scientific test and information stored in the brain revealed by the test, as Dr. Farwell did in the Harrington case (Harrington v. State 2001). Like the testimony of other forensic scientists, a brain fingerprinting scientist's testimony does not include interpreting the scientific evidence in terms of guilt or innocence.

Just as all witness testimony depends on the memory of the witness, brain fingerprinting depends on the memory of the subject. Like all witness testimony, brain fingerprinting results must be viewed in light of the limitations on human memory and the factors affecting it (Harrington v. State 2001, PBS 2004).

Brain fingerprinting can provide scientific evidence regarding what information is stored in a subject's brain. It does not determine what information should be, could be, or would be stored in the subject's brain if the subject were innocent or guilty. It only measures what actually is stored in the brain (Farwell 2012).

How this evidence is interpreted, and what conclusions are drawn based on it, is outside the realm of the science and the scientist. This is up to the judge and jury. It is up to the prosecutor and the defense attorney to argue, and the judge and jury to decide, the significance and weight of the brain fingerprinting evidence in making a determination of whether or not the subject committed the crime.

Like all forensic science techniques, brain fingerprinting depends on the evidence-gathering process which lies outside the realm of science to provide the evidence to be scientifically tested. Before a brain fingerprinting test can be conducted, an investigator must discover relevant information about the crime or investigated situation.

This investigative process, in which the investigator gathers the information to be tested from the crime scene or other sources related to the crime, depends on the skill and judgment of the investigator. This process is outside the scientific process; it precedes the scientific process of brain fingerprinting. This investigative process produces the probe stimuli to be tested. Brain fingerprinting science only determines whether the information tested is stored in the brain of the subject or not. It does not provide scientific data on the effectiveness of the investigation that produced the information about the crime that was tested. In this regard, brain fingerprinting is similar to other forensic sciences.

A DNA test determines only whether two DNA samples match, it does not determine whether the investigator did an effective job of collecting DNA from the crime scene. Similarly, a brain fingerprinting test determines only whether or not the information stored in the suspect's brain matches the information contained in the probe stimuli. This is information that the investigator provided to the scientist to test scientifically, based on the investigative process that is outside the realm of science.

In making their determination about the crime and the suspect's possible role in it, the judge and jury must take into account not only the scientific determination of "information present" or "information absent" provided by the brain fingerprinting test; they must also make common-sense, human, non-scientific judgments regarding the information gathered by the investigator and to what degree knowledge or lack of knowledge of that information sheds light on the suspect's possible role in the crime (Harrington v. State 2001, Farwell 1995a, Farwell 2012).

Brain fingerprinting is not a substitute for effective investigation on the part of the

investigator or for common sense and good judgment on the part of the judge and jury (PBS 2004).

CONCLUSION:

Brain fingerprinting is a revolutionary scientific technology for solving crimes, identifying perpetrators, and exonerating innocent suspects with a record of 100 percent accuracy in research with US government agencies, actual criminal cases and other applications. The technology fulfills an urgent need for governments, law enforcement agencies, corporations, investigators, crime victims, and falsely accused innocent suspects.

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