



Brain Fingerprinting

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Abstract— Any crime is bound to leave evidence, be it physical or mental. While physical evidences can be tampered with, a mental image is always permanent or in other words the brain is left with a print. This can be analysed using encephalography and understanding of the reactions of brain to stimuli pertaining to the crime, in a suspect. This paper shows brain fingerprinting as a forensic tool and its applications through its working.

Keywords— Brain fingerprinting, EEG, P300-MERMER, alpha, beta, theta, delta

I. INTRODUCTION

The one field that never ceases to exist as apparent as it may seem is crime. And the most important aspect is to know the actual criminal. This is the motive and only goal of the forensic department. However, forensics is not just limited to law enforcement alone. It is also applied to astronomy, archaeological inheritance trees and other extended fields. Many approaches are employed in forensic science today to serve its purpose of which, one that mainly holds interest is “Computational Forensics” which concerns the development of algorithms and software to assist forensic examination. Approaches like lie-detection have vulnerabilities that clearly exist. Computational forensics involves implementation of software and algorithms. These algorithms which once devised have a heavy scope of improvement and are obviously more reliable. Some such algorithms played a major role and some others which are playing a major role are processing fingerprints, shoeprints, documents, DNA, etc. Besides these available techniques, one new technique that is almost a revolution is the brain fingerprinting technique which was invented by Dr. Lawrence Farwell.

The fundamental difference between the perpetrator of a crime and an innocent person is that the perpetrator having committed the crime has the details of the crime stored in his memory while the innocent suspect does not. This is what Brain Fingerprinting testing detects scientifically by way of the presence or absence of specific information in his memory. But then, even the victim has the same image details as the criminal. This is identified by showing different visuals and measuring the intensity of signal generations. Brain Fingerprinting is a brain computer interaction. The working of brain is the basis for its development. It is known that every brain reacts to a particular stimulus. The response depends upon the previous encounter of the one with the same stimulus. Thus, it is a biological phenomenon implemented through computer aids which are algorithms and simulation algorithms..

II. WORKING

The technique involves the application of a series of stimuli to the accused in the form of pictures that are relevant to a crime, terrorist act, terrorist training, or specific knowledge or expertise are presented on a computer screen along with the irrelevant ones. The suspect’s brainwaves based on the responses to these stimuli are measured non-invasively using a patented headband equipped with Electroencephalography (EEG) sensors. A proprietary computer program then analyses the data to determine if the information related to the crime under question is stored in the brain. A measurable brain response known as a P300 is emitted by the brain of the criminal who has the details of the crime stored in his brain but not by an innocent suspect lacking this record in his brain. The P300 response has been extensively researched and widely published in leading professional journals for more than 30 years and has gained broad acceptance. The discovery of the P300-MERMER (Memory and Encoding Related Multifaceted Electroencephalographic Responses) by brain response allows the results gained through the P300 to be more accurate and 100% of such determinations have been correct



Fig. 1 EEG sensors

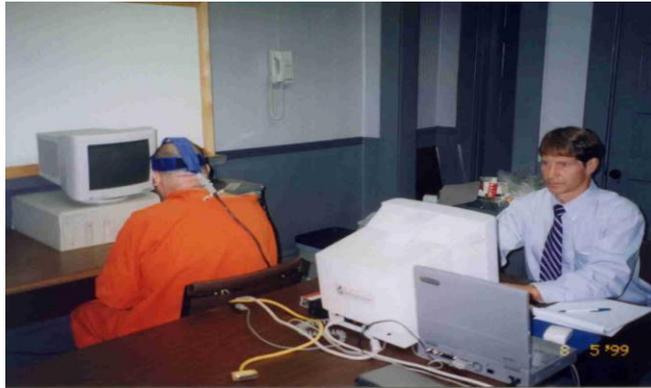


Fig. 2 Brain fingerprinting test by Lawrence A. Farwell

Phases in Brain Fingerprinting

Brain Fingerprinting is a process that involves four main phases

1. Investigating

The first phase in which an expert visits the crime scene and gathers all the details corresponding to the crime scene. These are necessary as we are supposed to show the pictures or words related to crime scene to the accused for further investigation. This investigation precedes and informs the scientific phase which constitutes the Brain Fingerprinting test itself. The role of investigation is to find specific information that will be useful in a Brain Fingerprinting test. As with any scientific test, if the outcome of the Brain Fingerprinting test is to be useful evidence for a judge and jury to consider in reaching their verdict, then the information tested must have a bearing on the perpetration of the crime.

2. Interviewing the subject

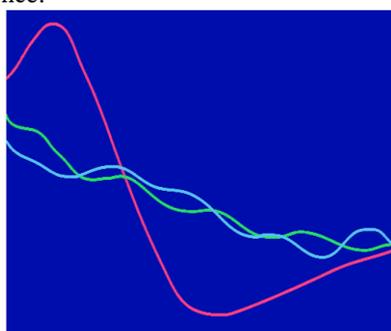
Once evidence has been accumulated through investigation, and before the Brain Fingerprinting test is conducted to determine if the evidence can be linked to the suspect, it can in some cases be very valuable to obtain the suspects account of the situation. It is a test for the match between the crime scene information and the evidence in the brain of suspect. It involves the usage of EEG sensors and Brain Fingerprinting system. If the suspects' story is that he was never at the scene of the crime, then a match between his fingerprints and the fingerprints at that scene would be highly incriminating. If, on the other hand, the suspects story is that he was at the scene for some legitimate reason just before the crime, then fingerprints must be interpreted differently, particularly if there is corroborating evidence of the suspects presence at the scene before the crime. Prior to a Brain Fingerprinting test, an interview of the suspect is conducted. The suspect is asked if he would have any legitimate reason for knowing any of the information that is contained in the potential probe stimuli. This information is described without revealing which stimuli are probes and which are irrelevant.

3. Scientific testing

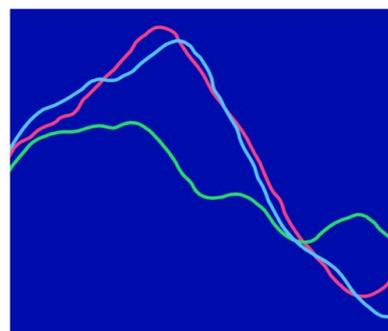
It is the plot and analysis of brain waves using a brain fingerprinting system which involves the application of complex mathematics for deciding the result which says whether suspect is a real culprit or innocent. The input for this scientific procedure is the probe stimuli, obtained from the previous steps. The output of this scientific procedure is a determination of "information present" or "information absent"(shown below) for those specific probe stimuli, along with a statistical confidence for this determination.

4. Result

The Result can be considered in two ways: "Information present"- details present in brain and "Information absent"- details absent in brain. Depending on the display of plot of brain waves which are also a part of result, it will be decided whether the information is present in the brain of a suspect or not. This will be solely judicial with the aid of scientific evidence.



Information is absent



Information is present

EEG group waves:

The analysis of continuous EEG signals or brain waves is complex, due to the large amount of information received from every electrode. Five types are particularly important:

1. Beta:

Beta is the brain wave usually associated with active thinking, active attention, and focus on the outside world or solving concrete problems. It can reach frequencies near 50 hertz during intense mental activity.

2. Alpha

Alpha is the most prominent wave in the whole realm of brain activity and possibly covers a greater range than has been previously thought of. It is frequent to see a peak in the beta range as high as 20 Hz. Alpha alone seems to indicate an empty mind rather than a relaxed one, a mindless state rather than a passive one, and can be reduced or eliminated by opening the eyes, by hearing unfamiliar sounds, or by anxiety or mental concentration.

3. Theta

Theta arises from emotional stress, especially frustration or disappointment. Theta has been also associated with access to unconscious material, creative inspiration and deep meditation. The large dominant peak of the theta waves is around 7 Hz.

4. Delta:

Delta waves are primarily associated with deep sleep, and in the waking state, were thought to indicate physical defects in the brain. It is very easy to confuse artefact signals caused by the large muscles of the neck and jaw with the genuine delta responses.

5. Gamma:

Gamma waves lie within the range of 35Hz and up. It is thought that this band reflects the mechanism of consciousness - the binding together of distinct modular brain functions into coherent percepts capable of behaving in a re-entrant fashion.

In recent studies, it has been found that the p300 wave signal was a coherence composition of alpha, delta and theta signals as opposed to previous studies where only delta and theta signals were considered.

In contrast-with other forensic tools:

1. The inevitable resort to any crime investigation is DNA. But what if the suspect never leaves one? That's where the science of brain fingerprinting finds its place.
2. Sometimes ballistic reports and other bite marks and other secondary evidences can become distorted over time but not a brains' image print. This solves a major time dependent issues regarding crime evidences.
3. Although hair matching proved convincingly efficient, scientists still claim to find that a single hair strand can be matched to 80 other persons provided you find the exact human premise.
4. Toxicology tests can prove to be unreliable sometimes on continuous testing with various other chemicals for its reaction to other chemical stimuli. Once tampered, it proves to be comparatively useless.

Applications:

1. To Counter National Threats:

In any crime or terrorist act, the brain of the perpetrator is always there -- planning, executing, and recording the crime. There may or may not be other kinds of evidence. Brain fingerprinting technology can identify the perpetrators and planners of terrorist acts by detecting the record stored in the brain. In addition, it could be used to identify trained terrorists.

2. Criminal justice

It has been proved to be true in 99.9% of cases in which it has been applied. So, it can be used to do criminal justice. Several instances have proven to do justice more than mere contemplating on barely available evidence like half-prints, etc.,

3. Medical Field:

In case of Alzheimer's patients can be tested for relation with any entity be it a person or a location as to whether they have a distinct recollection of the event or atleast a faint memory of it.

4. Advertising:

It can be used to know the "pulse of people" by examining the information in brains of people in response to the advertisements being used for publicity. Though it's a long shot it will be a reality in the near future.

Proofs of Reliability

1. Brain Fingerprinting Helped to Put a Serial Killer in Prison for Life:

Macon County, Missouri Sheriff Robert Dawson engaged Dr. Farwell to conduct a Brain Fingerprinting test on murder suspect JB Grinder. The test proved that the record stored in his brain matched the scene of the murder of Julie Helton He later confessed to the murders of three other young women in time.

2. Ruled Admissible in Court; Man Convicted of Murder Freed after 25 Years.

Terry Harrington was convicted of murder in 1978 in Iowa and sentenced to life in prison. Brain Fingerprinting testing proved that the record stored in Harrington’s brain did not match the crime scene, and did match his alibi. In a sworn statement admitted as evidence, Harrington’s accuser confessed that he had lied in the original trial to avoid being prosecuted for the crime himself. In a post conviction hearing, the judge ruled Brain Fingerprinting testing admissible, but stopped short of granting a new trial. Harrington appealed to the Iowa Supreme Court for a new trial based on Brain Fingerprinting testing and other evidence. The Supreme Court overturned Harrington’s conviction, and granted him a new trial based on constitutional rights violations in the original trial. The State elected not to re-try him, largely due to the recantation of the key witness that was elicited by his being confronted with the Brain Fingerprinting results. Harrington is now a free man.

Pros:

1. Based on the examples of success we can very well say that it’s effective for a large number of cases.
2. Apart from criminal proceedings it is a milestone in medical fields and is still unutilised in psychological fields which could definitely take it to a whole another level.

Cons:

1. It uses high end technology involving EEG sensors, diffusion tensor images and other positron emission tomography techniques. The equipment involved to make it feasible would definitely be very costly.
2. Not many cases can afford the use of this technique. Only the critically hyped or in other cases the financially affordable innocent can attempt to use brain fingerprinting. Thus its’ scope is very limited.
3. The availability of the equipment is not available everywhere.
4. The technique can only detect information from their memory that would place both at the scene of the crime and it cannot determine what their roles were, thereby creating a distinct possibility of an innocent eye-witness becoming a suspect of the crime and giving a dubious opportunity to the real culprit to create a situation of doubt.

III. FIGURES

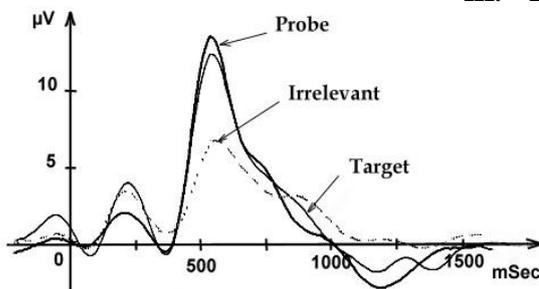


Fig. 3 Stimuli in the non-target category

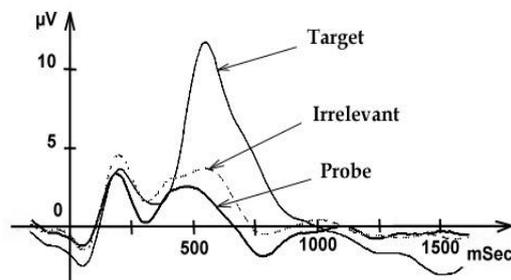


Fig. 4 Provoked MERMER event in a event

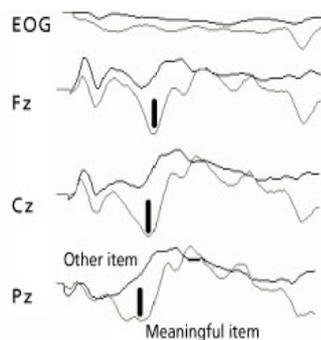


Figure 1. Three ERPs, based on our Rosenfeld et al. (2004) report, from the scalp sites Fz (frontal), Cz (central), and Pz (parietal). The sweeps are 2048 ms. long. P300 peaks are down-going and indicated with thick vertical lines. They are in response to meaningful information items. They are superimposed on responses to meaningless items. Given that the sweeps are about 2 s. long, the P300s begin around 400 ms. and end around 900 ms. Positive down.

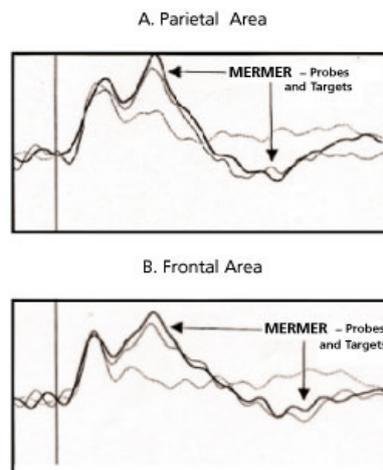


Figure 2. These are ERPs that are copied from the BF Web site, showing Pz (top) and Fz (bottom) ERPs. Positive is up, and the “MERMER” in response to targets and probes indicates two peaks with arrows; the first is the classic P300, and the second is the subsequent negative peak. The unlabelled waveforms not containing “MERMERS” are in response to irrelevant stimuli. (No timing information provided.)

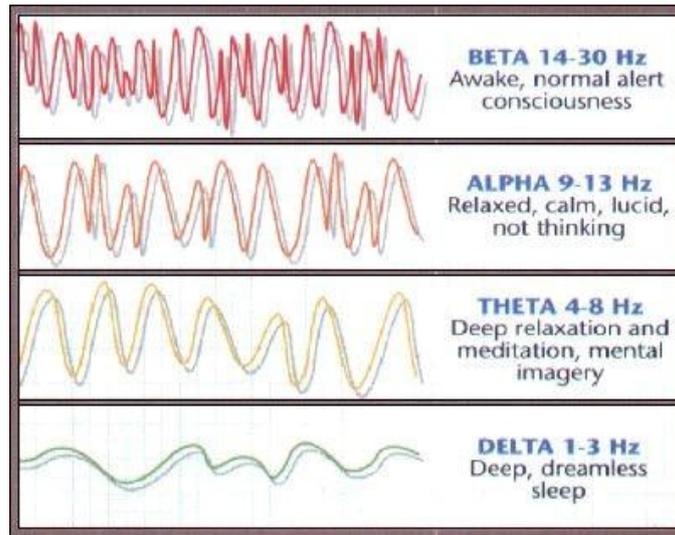


Fig. 5 Types of brain waves possible from response to external stimuli

IV. CONCLUSIONS

Brain fingerprinting is a proven powerful tool in forensic analysis in spite of the aforementioned cons. However given the rising stats in the crime sector we can't afford to simply rule out high rate of success that is inevitably visible from the many real-time applications in criminal proceeding, for instance. Brain fingerprinting in spite of its limitations is a definitive tool in revolutionizing the way criminal cases can be solved and also extending to medical and cases of national security. Thus, brain fingerprinting is a promise to a future void of tampered evidences or as a definite shot at humanitarian peace.

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