Review Article

Brain Fingerprinting: an Electrophysiological Marker for Detecting Lie

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Abstract

The classical methods of forensic science like finger printing, polygraphic lie detector test, narcoanalysis and DNA finger printing are being questioned for their reliability and accuracy. Newer developments in investigating crime are evolving like the use of ***event related evoked potentials*** to retrieve the sequence of events of crime as recorded in the brain of the criminal/accused.

The principle of ***event related evoked potentials*** is simple. In an oddball paradigm two stimuli of varying characteristics are presented to the individual, one repeated frequently and the other being rare, is given randomly at infrequent intervals. The subject is asked to respond to the infrequent or target stimulus by pressing a button. The response to target stimulus is recorded as P3 wave of the cognitive evoked potentials.

P3 wave of the ERPs has wide applications in cognitive forensic science and interrogative polygraphy in particular. Late vertex positivity in ERP reflects guilt detection in a test known as guilty knowledge. ***Memory and encoding related multifaceted electroencephalographic responses (MERMER)*** have been used to determine whether the subject had relevant information (committing of crime) in his brain, after presenting him with probing (relevant), target and non-target stimuli. Two high amplitude P3 waves are recorded in response to target and probing stimuli in case of a knowledgeable person and only one P3 in case of an innocent person.

The newly emerging, late responses to ERP is a step forward to quantify the thought processing feature of the brain. Brain wave science has emerged as a new discipline with promising application in field of crime investigation.

Key words: Event Related Evoked Potentials, MERMER, Target Stimulus, Probing Stimulus. P3 Wave, Long Latency Responses, Lie detection

Introduction

Forensic science employs classical methods like finger printing, polygraphic lie detector test, narcoanalysis and DNA finger printing but questions are being posed for their reliability and accuracy. There have been many recent advances in the science of investigating crime. One of these is the use of ***event related evoked potentials*** to retrieve the sequence of events of crime as recorded in the brain of the criminal or accused. Event related evoked potentials are long latency endogenous cerebral potentials indicating higher brain functions emanating from association and limbic areas. A brief overview of the classical methods is given below-

Polygraph lie detector: Sensors are attached to the body, and the polygraph machine records changes in breathing, blood pressure, pulse and perspiration. Control questions are asked first, that sets up a pattern of how an individual responds when giving true and false answers. A lie should cause a certain amount of stress that produces changes in several involuntary physiological reactions (such as blood pressure rising) [1]. However suspects dupe it by taking drugs like smoking and nicotine that calm the nerves and autonomic responses.

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. Also, DNA material may not be enough at the scene of crime also.

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Human brain is like a videocamera. It absorbs like a sponge from the environment. It is constantly being bombarded with mostly visual, auditory and some somatosensory stimuli from the ambient environment. These stimuli from the outside world result in an electrical evoked responses and events which are stored in the subconscious mind. These can be retrieved by brain fingerprinting. In the latter context, the controlled administration of intravenous hypnotic medications is called ***"narcosynthesis" or "narcoanalysis"***. It may be used to procure diagnostically- or therapeutically-vital information, and to provide patients with a functional respite from catatonia. The application of narcoanalysis has very limited use today as it requires medication and subjects cooperation.

Event related evoked potentials (ERP)

ERP technique is promising as it can provide an extraordinary means to find evidence which is not seen with the naked eye. This testing when used in reading criminal/accused's brain is known as brain fingerprinting and these ERP waves can see the truth locked in the accused's memory.

"Brain fingerprinting" is a computer-based test based on a very simple principle. The memory areas of human brain respond to the sight of familiar stimuli with a distinct change in electrical activity. It is designed to discover the P300 as a response to stimuli related to the crime or other investigated situation. It is used to document, and provide evidence of guilty knowledge regarding crimes, and to identify individuals with a specific training or expertise such as members of dormant terrorist cells or bomb makers. Thus it is an electrophysiological method of detemining whether certain information is stored in a brain or not stored. If the person has committed a crime he will have certain information relevant to the crime stored in his brain which can be retrieved with brain fingerprinting. The ERPs have also been used to evaluate higher brain functions in endocrine disorders [2], anaemia [3], cognitive information [4], epilepsy [5], chronic renal disease [6] and also as a means of early detection of cognitive impairment in caffeine users [7]. The technique uses the well known fact that an electrical signal known as P300 is emitted from an individual's brain beginning approximately 300 milliseconds after it is confronted with a stimulus of special significance, e.g. a rare vs a common stimulus the frequency of which the subject is asked to count. The person to be tested wears a special headband with electronic sensors that measures the EEG from several locations on the scalp. The subject views stimuli consisting of words, phrases, or pictures presented on a computer screen [8]. If he is attentive to the rare stimulus A positive P wave at 300 ms latency is recorded (P300).

MERMER

While researching the P300, Dr. Farwell created a more detailed test that not only includes the P300, but also observes the stimulus response up to 1400 ms after the stimulus. He calls this brain response a MERMER, memory and encoding related multifaceted electroencephalographic response. The P300, an electrically positive component, is maximal at the midline parietal area of the head and has a peak latency of approximately 300 ms. The MERMER includes the P300 and also an electrically negative component, with an onset latency of approximately 800-1200ms [8,9]. According to Dr. Farwell, the MERMER includes additional features involving changes in the frequency of the EEG signal, but for the purposes of signal detection and practical application, the MERMER is sufficiently characterized by the P300 and the following negative component in the brain response. Stimuli are of three types: 1) "irrelevant" stimuli that are irrelevant to the investigated situation and to the test subject, 2) "target" stimuli that are relevant to the investigated situation and are known to the subject, and 3) "probe" stimuli that are relevant to the investigated situation and that the subject denies knowing. Probes contain information that is known only to the perpetrator and investigators, and not to the general public or to an innocent suspect who was not at the scene of the crime. Before the test, the scientist identifies the targets to the subject, and makes sure that he/she knows these relevant stimuli. The scientist also makes sure that the subject does not know the probes for any reason unrelated to the crime, and that the subject denies knowing the probes. The subject is told why the probes are significant (e.g., "You will see several items, one of which is the murder weapon"), but is not told which items are the probes and which are irrelevant [9,10]. By comparing the responses to the different types of stimuli, the brain fingerprinting system mathematically computes a determination of "information present" (the

subject knows the crime-relevant information contained in the probe stimuli) or "information absent" (the subject does not know the information) and a statistical confidence for the determination. This determination is mathematically computed, and does not involve the subjective judgment of the scientist. MERMERs are thus elicited by probe stimuli only in the subjects who have participated in the investigated event, by target stimuli and not by irrelevant stimuli. In short it means, a person who has committed the crime or the one who is knowledgeable about the true events, MERMER is seen which consists of two well-defined P300 responses, one to relevant stimulus and the other to probing stimulus. Information absent response does not show MERMER but only one distinct P300 response to relevant (rare) stimulus. The probing stimulus is irrelevant for him as he has no knowledge of the crime.

Brain fingerprinting vs polygraphic test

The application of this in brain fingerprinting is to detect the P300 as a response to stimuli related to the crime or other investigated situation, e.g. a murder weapon, victim's face, or knowledge of the internal workings of a terrorist cell [8,11,12]. Since brain fingerprinting uses cognitive brain responses, it does not depend on the emotions of the subject, nor is it affected by emotional responses [13,14,15]. Brain fingerprinting is fundamentally different from the polygraph (lie-detector), which measures emotion-based physiological signals such as heart rate, sweating, and blood pressure [8]. Also, unlike polygraph testing, it does not attempt to determine whether or not the subject is lying or telling the truth. Rather, it measures the subject's brain response to relevant words, phrases, or pictures to detect whether or not the relevant information is stored in the subject's brain [10,12,16].

Application

Brain Fingerprinting Testing has been ruled admissible in court [17]. The Brain Fingerprinting system tests for knowledge of salient features of a crime stored in the brain. Scientists know that we don't remember everything, but we do remember significant features of major events, like committing a serious crime. By scientifically determining what is stored in a suspect's brain, Brain Fingerprinting testing provides evidence that can be used by judges and juries in making a determination as to whether the suspect committed the crime or not.

Brain Fingerprinting testing is used by FBI agents to apply this science in bringing criminals to justice and freeing innocent suspects [13,14,18]. It has been applied not only in rigorous laboratory studies but also in over 100 real-life cases, for a US intelligence agency and for the US Navy.

As with other scientific evidence, Brain Fingerprinting testing does not prove guilt or innocence per se. It provides information about what is stored in the suspect's brain. A judge or jury can utilize this information in making the legal determination of guilt or innocence

Limitations

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 [12].

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 [10]. 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.

Obviously, in structuring a brain fingerprinting test, a scientist must avoid including information that has been made public. Detecting that a suspect knows information he obtained by reading a newspaper would not be of use in a criminal investigation, and standard brain fingerprinting procedures eliminate all such information from the structuring of a test [1,19]. News accounts containing many of the details of a crime do not interfere with the development of a brain fingerprinting test, however; they simply limit the material that can be tested. Even in highly publicized cases, there are almost always many details that are known to the investigators but not released to the public and these can be used as stimuli to test the subject for knowledge that he would have no way to know except by committing the crime.

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. For example, brain fingerprinting can be used to detect whether a person has knowledge that would identify him as an FBI agent, an Al-Qaeda-trained terrorist, a member of a criminal organization or terrorist cell, or a bomb maker [12].

Brain fingerprinting 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 [19].

Key Points

Brain finger printing is a new technique which is useful in various fields. Brain fingerprinting" is a computer-based test that is designed to discover, document, and provide evidence of guilty knowledge regarding crimes, and to identify individuals with a specific training or expertise such as members of dormant terrorist cells or bomb makers.

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