

GAO

Report to the Honorable
Charles E. Grassley, U.S. Senate

October 2001

INVESTIGATIVE TECHNIQUES

Federal Agency Views on the Potential Application of "Brain Fingerprinting"



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Abbreviations

CIA	Central Intelligence Agency
DOD	Department of Defense
EEG	Electroencephalograph
FBI	Federal Bureau of Investigation
MERMER	Memory and Encoding Related Multifaceted Electroencephalographic Response
NIH	National Institutes of Health



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United States General Accounting Office
Washington, DC 20548

October 31, 2001

The Honorable Charles E. Grassley
United States Senate

Dear Senator Grassley:

Federal law enforcement and intelligence agencies use various techniques to assist them in criminal investigations and intelligence efforts and seek to identify new techniques to enhance their arsenal of investigative tools. You requested that we review a technique that has been proposed for use in the federal law enforcement and intelligence arenas, referred to as "Brain Fingerprinting." Its developer, Lawrence A. Farwell, Ph.D., has indicated that Brain Fingerprinting can be used as an investigative tool, with applications for law enforcement functions and intelligence operations. Specifically, the technique is designed to determine whether an individual recognizes certain details of an event or activity by measuring the individual's brain wave responses. In the past few years, several federal agencies—including the Central Intelligence Agency (CIA), Department of Defense (DOD), Federal Bureau of Investigation (FBI), and the Secret Service—have interacted, to varying degrees, with the developer to fund research or explore the technique for possible use in law enforcement or intelligence operations.

This report provides information on how Brain Fingerprinting is intended to work and federal agency views on its potential application. To obtain information on Brain Fingerprinting, we interviewed the developer, selected federal agency officials and three scientists in the field of psychophysiology,¹ who were familiar with the technique. Although our review did not constitute a technical analysis of Brain Fingerprinting, we provide the views of those three scientists in appendix I.

Results in Brief

Brain Fingerprinting is a proposed investigative technique that incorporates the use of a test administered to a subject that consists of specific information related to a particular event or activity. According to its developer, the technique requires a sufficient amount of specific

¹Refers to a branch of psychology that studies the interactions between physical or chemical processes in the body and mental states or behavior.

information about the event or activity that would be known only to the perpetrator and the investigator. The developer has indicated, therefore, that Brain Fingerprinting is not designed as a screening tool—a function that involves questioning a subject about events unknown to the investigator. In administering the Brain Fingerprinting test, a subject is shown a sequence of various stimuli on a computer screen in the form of words, phrases, or pictures—some that are related to the event or activity and others that are irrelevant. An electroencephalograph (EEG)² records the subject's electrical brain activity, which appears as a waveform. The technique employs a statistical method to analyze the components of the waveform to determine whether or not the subject recognizes the information. According to the developer, an investigator would be able to use this information as evidence for or against a suspect. For example, the developer has indicated that the technique could be used to determine whether a suspect has knowledge of details about a crime.

Officials representing CIA, DOD, Secret Service, and FBI do not foresee using the Brain Fingerprinting technique for their operations because of its limited application. For example, CIA and DOD officials indicated that their counterintelligence operations and criminal investigations do not usually lend themselves to a technique such as Brain Fingerprinting because use of the technique requires a unique level of detail and information that would be known only to the perpetrator and the investigators. These officials indicated that they need a tool to screen current and prospective employees, which as indicated above, involves questioning a subject about events unknown to the investigator. Further, a Secret Service official indicated that the agency has had a high success rate with the polygraph as an interrogative and screening tool and therefore saw limited use for Brain Fingerprinting. FBI Laboratory Division officials evaluated the technique in 1993 and 1999 and concluded that Brain Fingerprinting had limited applicability and usefulness in FBI investigations and personnel security and screening matters. In addition, the division concluded, among other things, that, given the technique's limitations, the research expenses, equipment, and training costs were perceived to exceed benefits. However, two FBI agents who collaborated

²An EEG records electrical activity of the brain from electrodes placed on the surface of the scalp.

with the developer on related research³ believe that Brain Fingerprinting has potential as an investigative tool. One of these agents stated that use of the technique would require a shift in FBI's investigative and training methods—a policy issue that would have to be addressed by FBI management. Furthermore, the three scientists we interviewed expressed a need for more research to demonstrate Brain Fingerprinting's application as an investigative tool.

In providing comments on a draft of this report, CIA, DOD, Secret Service, and FBI generally agreed with the report and our presentation of their views. (Written comments from the Secret Service and FBI are reprinted in appendixes II and III). In addition, the developer of the technique, Dr. Farwell, indicated that he had no comments or technical corrections on the report.

Scope and Methodology

As part of our data gathering efforts, we identified knowledgeable officials from selected federal intelligence and law enforcement agencies that had provided research funding for the Brain Fingerprinting technique, had explored use of the technique, or had engaged in related or direct research. Specifically, we spoke with officials at CIA; components of DOD, which included the DOD Polygraph Institute, National Security Agency, Defense Security Service, Army Criminal Investigation Command, Air Force Surgeon General's Office, and the Office of the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence; FBI; and Secret Service. At DOD, our substantive contact focused on officials from the DOD Polygraph Institute and Defense Security Service. For their collective views, we refer to these components as "DOD." Otherwise, we refer to them by their individual name. At FBI, we spoke with officials who had been involved in an evaluation of the Brain Fingerprinting technique. We also spoke with two FBI agents who had collaborated with the developer on related research. We interviewed these individuals because they had first-hand knowledge of the Brain Fingerprinting technique and experience with FBI investigative procedures. In addition, we reviewed and analyzed documents provided by those agencies that relate to Brain Fingerprinting and various forensic applications.

³Specifically, one of these agents conducted a graduate school research project with the assistance of the developer. This agent indicated that her views regarding the technique should therefore not be considered an endorsement by the FBI. The second agent indicated that the research that he conducted with the developer had been requested and approved by the FBI in 1992.

To gain an understanding of the science underlying Brain Fingerprinting, we interviewed researchers at the National Institutes of Health (NIH), three scientists in the field of psychophysiology, and the developer of the technique. We selected these scientists on the basis of recommendations made by the agency officials we interviewed, researchers we spoke with at NIH, and the developer. In addition, two of the scientists we spoke with had testified in Harrington v. Iowa, the one court case we have identified that has addressed Brain Fingerprinting evidence.⁴ In providing their views, these scientists helped us understand the underlying methods of Brain Fingerprinting and its potential application as an investigative tool. We have included a summary of their views in appendix I of this report. Their views are not meant in any way to represent the views of the scientific community as a whole.

Furthermore, as part of our research efforts, we identified and reviewed available documentation, including articles, studies, reports, and other relevant materials in the related fields of psychophysiology, neuroscience, and forensics. Our search for information related to Brain Fingerprinting revealed that only a limited amount of independent documentation exists about the technique and its uses for law enforcement and intelligence. We also reviewed court documents in Harrington v. Iowa and interviewed the prosecuting attorney in the case.

We did not perform a technical analysis of Brain Fingerprinting. That is, we did not independently assess the hardware, software, or other components of the technology nor did we attempt to determine independently whether Brain Fingerprinting is a valid technique.

We performed our work from January 2001 to August 2001 in accordance with generally accepted government auditing standards.

Background

Several federal agencies are involved in researching, developing, or using techniques to detect deception and have interacted, to varying degrees, with the developer since the early 1990s. CIA's Directorate of Science and Technology researches, develops, and applies enabling technologies in support of the agency's mission to collect, process, and analyze foreign intelligence and counterintelligence information. From 1991 to 1993, the Directorate's forerunner, the Office of Research and Development, funded the developer about \$1 million for research involving experimental studies

⁴Harrington v. Iowa, No. PCCV 073247 (Dist. Ct. Iowa, Mar. 5, 2001).

designed to evaluate and improve techniques for detecting concealed information using electrical brain wave measurements.⁵

Components within DOD, including the DOD Polygraph Institute and Defense Security Service,⁶ are involved with detection of deception research, such as brain wave research, and are knowledgeable about Brain Fingerprinting. The Polygraph Institute's research mission is to evaluate the validity of psychophysiological detection of deception techniques used by DOD and other agencies, investigate countermeasures (i.e., deliberate techniques used by deceptive subjects to avoid detection during a polygraph examination) and anticountermeasures, and conduct developmental research on psychophysiological detection of deception techniques, instrumentation and analytic methods. According to the Polygraph Institute, the agency's most recent contact with the developer occurred in 1999, when he met with the Chief of Research to discuss the Polygraph Institute's grants program.

Within FBI, the Laboratory Division researches, develops, and deploys new forensic techniques and technologies. The Division evaluated the Brain Fingerprinting technique in 1993 and 1999. In addition, two agents within FBI's Behavioral Science Unit⁷ and the Laboratory Division had collaborated with the developer on related research in 1992 and 1993.

The Secret Service's Forensic Services Division, which manages its polygraph programs nationwide, conducts examinations involving criminal, national security, and employee screening matters. In 1998, a representative of the developer had contacted the division in an effort to provide the agency with information on the technique. The division

⁵In the mid- to late 1980s, CIA also contributed funding to a collaborative effort on brain wave detection of deception research conducted by the developer and another scientist.

⁶As a federally funded agency, the Polygraph Institute's purpose is to qualify DOD and non-DOD federal personnel for careers as forensic psychophysiologicals; provide continuous research in forensic psychophysiology and credibility assessment methods; manage the continuing education certification program for all federal agencies; and manage the Quality Assurance Program that maintains quality standards and provides technical assistance to the federal polygraph programs. In 1997, operational responsibilities for the Polygraph Institute were placed within the Defense Security Service.

⁷Located in FBI's Training Division, the Behavioral Science Unit conducts forensic research with a focus on new and innovative investigative approaches related to offender psychology and behavior.

subsequently reviewed the information and consulted with a CIA official because of the official's knowledge of and experience with the technique.

How Brain Fingerprinting Is Intended to Work

According to its developer, 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 when 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 regard, Brain Fingerprinting is considered a type of Guilty Knowledge Test.⁸ Only the guilty party is expected to react strongly to the relevant details of the event or activity. Its developer has indicated that Brain Fingerprinting, therefore, is not designed for screening functions, which involves questioning individuals about events unknown to the investigator. Rather, the developer has indicated that an investigator would be able to use this information as evidence for or against a suspect. For example, he has indicated that the technique could be used to determine whether a suspect has knowledge of details connecting him or her to a crime.

Brain Fingerprinting uses an EEG to record distinct patterns of brain activity. These patterns, called event-related potentials, are measures of the brain's electrical activity or "potentials" as they correspond to stimuli or "events" in the environment. By averaging the distinct patterns of electrical activity, a singular waveform is created that is generally dissected into various components associated with cognitive functions. The event-related potential components relevant to Brain Fingerprinting are the P300 and the Memory and Encoding Related Multifaceted

⁸There are two behavioral paradigms that have been used in detecting deception: the Guilty Knowledge Test and Control Question Test. Generally, a Guilty Knowledge Test involves presenting a subject with a series of questions, some of which are relevant to the crime in question and some of which are irrelevant to the crime. It is expected that a subject who possesses "guilty knowledge" will respond differently to the crime-relevant questions than to the irrelevant questions, while an innocent individual will respond no differently to the crime-relevant than to the irrelevant questions. A Control Question Test, in contrast, involves relevant questions directly related to the crime, irrelevant questions unrelated to the crime, and control questions. The control question is designed to inquire about general criminal behavior that a large portion of the population may have done and that has nothing to do with the crime under investigation, such as "When you were a teenager, did you ever steal anything?" It is expected that the control question will elicit an emotional response in the innocent subject that exceeds the response to the relevant question, while the relevant question will elicit the larger emotional response in the guilty subject.

Electroencephalographic Response (MERMER). The P300 component has been recognized by the scientific community as an electrically positive charge that peaks between about 300 and 500 milliseconds in response to rare, meaningful, or noteworthy stimuli. The MERMER, patented by the developer, includes the P300 and subsequent electrical changes occurring at about 800 to 1200 milliseconds after a stimulus has been presented to a subject. According to the developer, MERMER has not undergone independent peer review testing and is not well accepted in the scientific community.

The developer has indicated that use of the Brain Fingerprinting technique should involve the following procedure. An examiner or investigator with expertise in the Brain Fingerprinting technique reviews and identifies evidence related to an event or activity through various means, such as personal interviews, police records, court testimony, crime scene photos or a crime scene. From this information, the examiner or investigator chooses the stimuli to present to the subject in the form of words, phrases, or pictures, which are flashed on a video monitor under computer control. The three types of stimuli are categorized as “targets,” “irrelevants,” and “probes.” Targets are made relevant and noteworthy to the subject by giving him or her a list of the targets before the test is administered. Since they are noteworthy, they should elicit a P300 response. A second set of stimuli are irrelevant to the event or activity, although they could be plausible substitutes for actual details of the event or activity. These stimuli should not elicit a P300 response. Interspersed with the irrelevant stimuli are less frequent stimuli called probes. Probes are unique details of the event or activity that are supposed to be known only to the examiner or investigator and the subject. For a subject with knowledge of the event or activity, probes should elicit a P300. For a subject lacking that knowledge, probes should be indistinguishable from the irrelevants and should not elicit a P300.

The responses to the three types of stimuli are compared using a statistical method,⁹ which according to the developer, can yield an “information

⁹This refers to bootstrapping, which is a nonparametric statistical technique for inferring the distribution of a statistic from a sample and for determining how reliable that statistic is as a measure for the population. As a type of resampling, bootstrapping randomly generates an entire distribution of values using data from just one sample and allows one to make inferences with an associated degree of confidence about a population parameter, such as a mean, median, or total. Bootstrapping provides a means to estimate standard errors of sample statistics without requiring assumptions about the distribution of the underlying population.

present” (i.e., the subject recognized the information) or “information absent” (i.e., the subject did not recognize the information) result. According to the developer, Brain Fingerprinting, using P300 analysis, can yield results with a statistical confidence level in excess of 95 percent. He has further stated that MERMER provides the same results as the P300, but with a higher confidence level—99 percent or more—because it records more data points. In addition, he has stated that his research trials have resulted in a 100 percent accuracy rate for determinations of information present or information absent.

In April 2000, the developer administered the Brain Fingerprinting test to an individual convicted of murder in Iowa in 1978. In November 2000, this individual subsequently petitioned an Iowa district court for postconviction relief, arguing, among other things, that the Brain Fingerprinting test results demonstrated his innocence. The court addressed the Brain Fingerprinting evidence in a written ruling dismissing the application for postconviction relief. The court ruled that the Brain Fingerprinting evidence was unlikely to have changed the result of the defendant’s trial. In this regard, the court observed that, although the P300 effect was well established, neither the MERMER nor the developer’s mathematical model was well accepted in the scientific community or had been subject to independent testing or peer review. The court also remarked that the selection of probe stimuli was subjective and did not, in this case, meet the developer’s own selection criteria because various stimuli were not sufficiently significant or had been disclosed to the defendant at trial.¹⁰

Federal Agency Views on Brain Fingerprinting’s Potential Application

CIA, DOD, FBI, and Secret Service do not foresee using the Brain Fingerprinting technique for their operations because of its limited application. Both CIA and DOD officials, for example, expressed the need for a tool for screening purposes, for which Brain Fingerprinting is not designed. The Secret Service indicated that the agency has had a high success rate with the polygraph as an interrogative and screening tool and therefore saw limited use for the technique. Within FBI, the Laboratory Division concluded that Brain Fingerprinting had limited applicability to

¹⁰See Harrington v. Iowa, No. PCCV 073247 (Dist. Ct. Iowa, Mar. 5, 2001). The Harrington court applied Iowa law to the facts of the case. We did not identify any federal court opinion addressing P300 or MERMER technology.

FBI's investigative and screening functions and identified other research and operational concerns that would preclude its usefulness.

CIA Views

From their experiences with the developer's research between 1991 and 1993, CIA officials concluded that Brain Fingerprinting had limited applicability to CIA's operations. Accordingly, CIA decided that it was not worth investing more funds to continue the developer's research. Specifically, CIA officials told us that the technique had limited application to CIA activities because it did not have a screening capability, which is of primary interest to CIA. These officials explained that to administer Brain Fingerprinting, an investigator must know enough details of a particular event to test an individual for knowledge of that event. For example, these officials said that using Brain Fingerprinting to determine an agent's involvement in espionage would be difficult because the investigator would be hard-pressed to identify unique stimuli; in counterintelligence, specific details are not always available because spying is not always known to have taken place. Moreover, CIA officials indicated that a perceived operational limitation of the technique was that it required a trained scientist to administer the Brain Fingerprinting test.

In addition, CIA officials indicated that as an ordinary step in evaluating advanced research and development work, the agency had assembled a panel of independent researchers in 1993 to assess the analytic methods employed by the developer to ensure that they were scientifically sound and defensible. CIA officials stated that while the panel indicated that the technique appeared interesting, it was not able to assess the validity of the work because the developer would not provide the algorithmic information that was critical to completing such an assessment. According to CIA officials, the developer considered the information proprietary. Those officials indicated that no additional research funding was provided following the panel evaluation.

DOD Views

Overall, DOD officials indicated that Brain Fingerprinting has limited applicability to DOD's operations. According to these officials, DOD priorities are for screening prospective and current employees. However, as acknowledged by its developer, Brain Fingerprinting is not designed as a screening tool. DOD's Polygraph Institute indicated that, with a limited budget of \$400,000 a year, it focuses its resources on conducting research related to employment screening techniques, which is a major area of interest for DOD. The Polygraph Institute also indicated that it is currently funding other brain wave detection of deception research, which the agency believes may lead to applications that could meet DOD's needs.

Regarding Brain Fingerprinting's applicability to criminal investigations, DOD officials acknowledged that DOD conducts a limited number of specific issue examinations where the technique could be applied. DOD officials indicated that most DOD criminal investigations do not lend themselves to a Guilty Knowledge Test-based technique, such as Brain Fingerprinting, because these kinds of investigations typically lack the specific information that is needed for administering such a test and because knowledge of the discrete elements of an event or activity may not be limited to only the investigator and the perpetrator.

FBI Views

According to FBI officials, in 1993, the Laboratory Division's Polygraph Unit and CIA collaborated in an effort to evaluate and validate the Brain Fingerprinting test. At that time, the Polygraph Unit concluded the following.

- The developer had not presented sufficient information to demonstrate validity or the underlying scientific basis of his assertions. For example, the FBI asked the developer to provide details of all tests conducted, particularly in a law enforcement setting, which would support validation. FBI officials indicated that the developer maintained that his technique was proprietary.
- The technique had limited applicability and usefulness to FBI investigative and personnel security matters.
- The research expenses, equipment, and training costs exceeded any perceived benefit.
- According to the developer, only individuals with advanced academic degrees—trained in psychophysiology or a related science—could be used to operate the system. The Polygraph Unit indicated that this eliminated a large segment of the FBI population as potential operators.

FBI officials indicated that, in 1999, the Laboratory Division assembled a panel of reviewers and conducted another evaluation of the technique, based on a demonstration provided by the developer. The panel concluded that since substantially no additional research had been done since 1993, the conclusions that had been reached at that time had not changed.

In addition, the panel raised concerns about the technique's limited utility for employment screening applications and security matters. Furthermore, the panel indicated that the developer had not done research on the effects of external variables on brain activity, such as drugs, alcohol, or hallucinogenic drugs. FBI officials who participated in the panel explained that Brain Fingerprinting relies on retained memory, which they do not

believe is always a reliable record of events. Thus, they were concerned about possible changes or deletions from memory. These officials further explained that, as part of evaluating the validity of Brain Fingerprinting as an investigative technique, they must understand the effects of alcohol and other drug use on the brain in its processes for storing and retrieving information.

Separately, two FBI agents who had conducted research with the developer expressed a different view. These individuals, in the Behavioral Science Unit and Laboratory Division, believe that Brain Fingerprinting has potential for use in FBI criminal investigations. Both agents, however, recognize that FBI's current investigative techniques and practices do not require documenting the type of incidental crime scene information that could be used in constructing the probe stimuli. Specifically, they indicated that FBI agents and investigators do not record this kind of detailed information on the form that FBI uses to document crime scene information during an investigation. One of these agents pointed out that these investigators and agents would need to be trained in collecting specific and detailed crime scene information—such as the color of a sofa—that may not normally appear relevant at a crime scene or that had nothing to do with the crime committed, but could prove important as a probe stimulus. This agent also indicated that FBI would need to establish a means for protecting the crime scene information from public disclosure so as not to jeopardize the integrity of the test. The agent pointed out, however, that FBI's use of this technique would require a shift in FBI's investigative and training methods, which is essentially a policy issue that would have to be addressed by FBI management.

One of these agents believes that while Brain Fingerprinting is ready for forensic application, it could benefit from continued research and development, such as refining the probe stimuli and determining whether certain types of probes are more likely to be remembered than others.¹¹ In addition, this agent indicated that because drugs and alcohol are frequently used in committing crimes, research is needed to determine what effect they may have on memory. The second agent believes that Brain Fingerprinting is not ready for operational use and needs more research to be able to establish its viability in criminal cases.

¹¹Toward the latter part of our review, this agent retired from the FBI and is currently a business associate of the developer.

Secret Service Views

An official representing the Forensic Services Division indicated that, in 1998, the Secret Service reviewed information provided by the developer and consulted with a CIA official because of the official's knowledge of and experience with the Brain Fingerprinting technique. The Service subsequently concluded that the technique had limited application to Secret Service activities. The official further indicated that the agency has had a high success rate with the polygraph as an interrogative and screening tool.

Agency Comments and Our Evaluation

In letters dated October 5, 2001, we requested comments on a draft of this report from CIA, DOD, Secret Service, FBI, and the developer of the Brain Fingerprinting technique, Dr. Farwell. In addition, we requested that the three scientists we interviewed—Drs. Donchin, Iacono, and Rosenfeld—review our summaries of their views for technical accuracy and clarification.

Overall, CIA, DOD, Secret Service, and FBI agreed with the report and our presentation of their views. On October 17, 2001, we met with Dr. Farwell to discuss the draft report. At that time, he indicated that he had no comments or technical corrections on the report. In addition, Drs. Donchin, Iacono, and Rosenfeld separately provided technical comments and clarifications, which we have included where appropriate.

CIA and DOD provided oral comments on a draft of this report. Specifically, CIA's Directorate of Science and Technology indicated agreement with the contents of the report and had no other comments. DOD's Office of the Assistant Secretary of Defense for Command, Control, Communications and Intelligence indicated DOD's concurrence with the report and restated its position that the Brain Fingerprinting technique had limited application to DOD's operations.

The Forensic Services Division of the Secret Service provided written comments that essentially reiterated its position that Brain Fingerprinting had limited applicability to the Secret Service. Those comments are included in appendix II.

FBI's Office of Public and Congressional Affairs provided the Bureau's oral comments, which we have incorporated in this report. The Office also submitted the Bureau's written comments, which we have included in appendix III. Specifically, FBI indicated that the report fairly reflected the FBI's position that the technique has limited applicability and usefulness to FBI investigative and personnel security matters. Further, FBI indicated that—on the basis of its own research in forensic science and the scientific

views expressed in this report—it strongly disagreed with one of its agents' assessments of the technique. As discussed earlier in the report, this agent had indicated that while the technique could benefit from continued research and development, it was nevertheless ready for forensic application.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its date. At that time, we will send copies to appropriate congressional committees; the Attorney General; Secretary of DOD; Directors of CIA, FBI, Secret Service, and Office of Management and Budget; and other interested parties. Copies of this report will also be available to others on request.

If you or your staff have any questions, please call Linda Watson or me at (202) 512-8777. Key contributors to this report were Christine Davis, Sam Hinojosa, Brenda Rabinowitz, Keith Rhodes, and Anne Rhodes-Kline.

Sincerely yours,

A handwritten signature in cursive script that reads "Paul L. Jones". The signature is written in black ink and is positioned above the printed name and title.

Paul L. Jones
Director, Justice Issues

Appendix I: Scientists' Views on the Brain Fingerprinting Technique

The purpose of this appendix is to provide additional information on the Brain Fingerprinting technique. Specifically, we interviewed three scientists who were familiar with the technique: Emanuel Donchin, Ph.D.; William Iacono, Ph.D.; and J. Peter Rosenfeld, Ph.D. Each scientist shared his view of the technique, raising questions and providing insights related to some of the methods that underlie Brain Fingerprinting. These scientists expressed a need for more research to demonstrate Brain Fingerprinting's application as an investigative tool. However, these views are not representative of scientists' views in general, nor do they represent a complete or systematic review of the technique. The following sections provide the views of the three scientists.

Views of Emanuel Donchin Dr. Donchin¹ co-authored a journal article with Dr. Farwell in 1991 in which use of the P300 in a Guilty Knowledge Test was first described.² Dr. Donchin believes that the procedure described in the article (labeled more recently as "Brain Fingerprinting" by Dr. Farwell) utilizes the scientifically well-established observation that rare events (i.e., stimuli) presented within the so-called "oddball paradigm"³ will elicit a P300 component of the event-related potential. He indicated that a large body of peer-reviewed scientific literature, developed since 1965, supports this observation. However, Dr. Donchin believes that the specific application of the oddball

¹Dr. Donchin, Professor Emeritus of psychology at the University of Illinois at Urbana-Champaign and current professor and chair of psychology at the University of South Florida, has done extensive research in event-related potentials, the P300, and memory processes. He also served as the developer's academic advisor during his doctorate studies at the University of Illinois, and, in this capacity, conducted detection of deception research with him that was funded, in part, by the CIA in the late 1980s.

²See L.A. Farwell, and E. Donchin, "The Truth Will Out: Interrogative Polygraphy ('Lie Detection') With Event-Related Brain Potentials," *Psychophysiology* 28 (5): 531-47.

³The Brain Fingerprinting technique is a variant of the "oddball paradigm," which has been widely used by cognitive neuroscientists to evoke a P300 wave in an event-related potential recorded from the scalp. As indicated earlier, the P300 is an electrically positive charge that is elicited in response to rare, meaningful stimuli, and event-related potentials are measures of the brain's electrical activity as they correspond to those stimuli. The classic way to evoke the P300 is to present stimuli to a subject using the oddball paradigm. In this paradigm, two categories of stimuli are presented to a subject, but one of these categories appears more infrequently than the other. Research has shown that each time a subject is presented with the less frequent stimuli, the P300 is elicited. For example, if a subject is viewing a random series of names—one every 3 seconds—and occasionally, one of these names is the subject's, a P300 wave is evoked in response to this rarely presented, yet meaningful stimulus. The amplitude of the P300 is inversely proportional to the probability of the "oddball" stimuli. As a variant of the oddball paradigm, the Brain Fingerprinting technique uses three categories of stimuli.

paradigm for interrogations requires much further research. For example, he believes that the effectiveness of the Brain Fingerprinting test and its validity depends to a large extent on the events (i.e., stimuli) of which the oddball sequence is constructed. Specifically, he believes that the interpretation of the Brain Fingerprinting test results depends on the selection of the probe stimuli, which is left to the examiner's subjective judgment and skill in utilizing the available case information. Dr. Donchin indicated that a consequence of using a subjective method for choosing probe stimuli is the possibility of producing "false positives" (i.e., an innocent subject that would test positive when presented with a probe stimulus) or "false negatives" (i.e., the items chosen as probes because of their presumed association with the crime may not have been noticed by the subject during the commission of the crime). As an example, he provided a hypothetical case in which a person's involvement in a crime was inferred from the fact that the person produced a P300 response to pictures of people who were present at the crime scene. He said that the possibility exists that these individuals resemble close relatives of the suspect, resulting in an elicitation of a P300 response that could be misinterpreted as an indication of guilt. Dr. Donchin believes that a more systematic and objective method for identifying and choosing the events for use in the oddball sequence is needed before the technique could be trusted to yield unambiguous determinations.

Dr. Donchin also indicated that he believes it is important to realize that memory is an active, creative process and not a passive repository of stored images. He believes that while the P300 is a well-established and documented phenomenon for determining whether an event (i.e., stimulus) has been classified as an item of a rare category, it is not clear that every item that is classified is one to which the person has been exposed to in the past. He referred to the phenomenon of "false memory" and said he believes that research has amply demonstrated that individuals can report a vivid memory that may be quite false. For example, a subject presented with a list of sleep-related items—such as "bed," "sheet," "dream," and "snore"—will be certain that he or she had also been presented with the word "sleep," even though it had not been included among the items presented. Dr. Donchin pointed out that the "falsely recognized item," however, will elicit a sizable P300 response.

In addition, Dr. Donchin believes that more research is needed to understand the effects of age; substances, such as alcohol and drugs; and psychological disorders on memory and the P300.

Views of William Iacono

Dr. Iacono⁴ believes that Brain Fingerprinting is based on a documented and well-established phenomenon—the P300 response—as an indicator of a novel or unexpected stimulus event. However, he indicated that far fewer studies have examined the P300's potential to identify memories that are stored in an individual's brain. Hence, as an indicator of memory, the technique is less established.

Dr. Iacono believes that the Brain Fingerprinting technique is in its early stages of development and could benefit from more field research and testing before being applied to actual criminal investigations for the following reasons. For one, he believes that research has shown that investigating a murder in the field is entirely different from investigating a murder in a lab. Further, he believes that the technique could benefit from additional field research and testing to develop the probe stimuli. He believes that selecting the appropriate probe stimuli can be a subjective process, which he does not perceive as a criticism of the technique. However, he suggests that additional field research and testing be done on real-life applications to help identify which probes are better suited for the test. He also suggests a need for more field research to determine the effects that drugs and alcohol intoxication—at the time the crime is committed—may have on subsequent measurement of the P300. In addition, he believes that it is possible that certain drugs taken at the time of the Brain Fingerprinting test could affect memory and thus, the validity of the test. Dr. Iacono does not believe adequate research has been done in this area to understand the effects of these chemicals on the Brain Fingerprinting test. He added that although Brain Fingerprinting is unproven in the field, he is confident that it will prove itself for many applications, such as the investigation of carefully planned premeditated crimes.

⁴Dr. Iacono, a professor of psychology and neuroscience at the University of Minnesota, has done extensive research in the area of deception detection and memories related to deception.

On a separate issue, Dr. Iacono indicated that he employed the same statistical method⁵ and decision rules the developer used in the 1991 article by Farwell and Donchin, which Dr. Iacono noted have been peer reviewed and are well established in the scientific community. Dr. Iacono stated that he assumes that the developer is still using those decision rules in interpreting the results of the Brain Fingerprinting test. However, Dr. Iacono indicated that he has not replicated the decision rules that the developer used after the 1991 article.

Views of J. Peter Rosenfeld

Dr. Rosenfeld⁶ believes that a considerable amount of research and field testing is necessary to establish the validity of event-related potential measures in detecting deception using a Guilty Knowledge Test. He indicated that only one field test has applied the Guilty Knowledge Test in a law enforcement setting, which resulted in an accuracy rate of about 44 percent.⁷ In addition, Dr. Rosenfeld does not believe that the developer had done the extensive validation of the test items for field use that has

⁵Dr. Iacono refers to the previously mentioned 1991 journal article by Farwell and Donchin that involved the feasibility of using event-related potentials based on a Guilty Knowledge Test. That research employed a bootstrapping method. As indicated earlier, bootstrapping is a nonparametric statistical technique for inferring the distribution of a statistic from a sample and for determining how reliable that statistic is as a measure for the population. As a type of resampling, bootstrapping randomly generates an entire distribution of values using data from just one sample and allows one to make inferences with an associated degree of confidence about a population parameter, such as a mean, median, or total. Bootstrapping provides a means to estimate standard errors of sample statistics without requiring assumptions about the distribution of the underlying population.

⁶Dr. Rosenfeld, a professor of psychology and member of the Institute for Neuroscience at Northwestern University, has done extensive research in electroencephalograph and event-related potential signs of psychological function, with a particular focus on the P300, false memory, and brain activity in deception detection.

⁷Dr. Rosenfeld refers to a 1993 study by Y. Miyake, M. Mizutani, and T. Yamahura, "Event-Related Potentials as an Indicator of Detecting Information in Field Polygraph Examinations," *Polygraph* 22 (2): 131-49.

been recommended by the Guilty Knowledge Test's main proponent.⁸ Specifically, he believes that in administering the Brain Fingerprinting test to the defendant in the Harrington case, the developer used "art rather than science" in developing the stimuli that were administered to the defendant. He questioned how one would know whether the items selected for a guilty knowledge scenario would be sure to work on any guilty party. In addition, Dr. Rosenfeld said he believes there has been only one peer-reviewed journal article—the 1991 Farwell and Donchin article previously mentioned—that includes the developer's methods.

Dr. Rosenfeld also indicated he does not believe that memory automatically stores all of life's experiences forever. He indicated that current research has shown that memory is affected by various chemicals and conditions, such as alcohol and drugs, brain damage, mental illness, and extreme anxiety, during crime situations. He pointed to the example of extreme anxiety, suggesting that if someone just killed his wife, anxiety might prevent him from noticing what color shoes she was wearing. He does not believe the developer has done research on these issues.

In terms of the Brain Fingerprinting's test results, Dr. Rosenfeld questioned the developer's claim of a 100-percent accuracy rate. For example, he raised concerns regarding whether the developer omitted inconclusive results from the totals, which would affect the overall accuracy rate. Further, Dr. Rosenfeld believes the accuracy rate would be lower in the field, where variables cannot be so well controlled. Moreover, he believes that the developer's criterion for guilt is that 90 percent of the bootstrapping iterations of his analysis be positive. Dr. Rosenfeld stated that, in experimental psychology journals, the 95-percent criterion is generally used and that too lenient a criterion will ordinarily make more

⁸The Guilty Knowledge Test was introduced by David Lykken, Ph.D., a psychologist and former professor of psychiatry at the University of Minnesota, and polygraph critic. In his book, *A Tremor in the Blood*, Dr. Lykken has recommended that a Guilty Knowledge Test include probes that satisfy certain conditions. Specifically, he recommended that for each probe, an innocent subject should have no more than a 20-percent chance of testing positive and a guilty subject should have at least an 80-percent chance of testing positive. Each probe should have five alternatives that are equally plausible to an innocent subject, but, to the guilty subject, are easily distinguishable from the probe and from each other, so that the guilty subject is not confused about which alternative he or she has seen before. In addition, the fact that a guilty subject recognizes a probe "must seem important to the guilty subject," a condition that should always be realized in a criminal investigation context but may not be in some laboratory experiments.

guilty decisions but will also produce more false positives (i.e., innocents judged guilty).

Furthermore, Dr. Rosenfeld believes that the P300 is a good index of recognition, but an indirect index of deception. It assumes that if the subject states that he or she does not recognize the murder weapon, yet elicits a P300 when he or she sees it, then the subject is lying. He adds that such a conclusion leads to a reasonable, but not infallible inference that the subject is lying. However, a P300 response only indicates that there is something special and recognizable to him or her about that weapon—maybe because the subject committed the murder, but maybe because he or she read about the weapon in the news or because a brother has such a weapon. Dr. Rosenfeld indicated that there are no direct deception indices known at present but noted that researchers are working on one.

Appendix II: Comments From the U.S. Secret Service



DEPARTMENT OF THE TREASURY
UNITED STATES SECRET SERVICE

Forensic Services Division
950 H Street, N.W. Room 4200
Washington, D.C. 20001

October 16, 2001

Paul L. Jones
Director, Justice Issues
United States General Accounting Office
Washington, DC 20548

Dear Director Jones,


Reference is made to your draft report, dated October 1, 2001, entitled INVESTIGATIVE TECHNIQUES – Federal Agency Views on the Potential Application of "Brain Fingerprinting".

The Forensic Services Division, specifically Dr. Antonio Cantu, Chief Forensic Research Scientist, was contacted by Dr. Farwell in 1998 to review the "Brain Fingerprinting Technique". After reviewing this technology, and consulting with other individuals within the intelligence community, Dr. Cantu concluded that this technology had extremely limited applicability to the Secret Service.

Dr. Cantu has recently briefed me on this technology and the underlying scientific principals, which purportedly support its accuracy and validity. Following this briefing, and a review of the information related to this technique, I must concur completely with the opinion of Dr. Cantu. The "Brain Fingerprinting Technique" has very little applicability to the overall Secret Service mission, and is a technology that has not been completely validated as of this time.

Should you have any further questions regarding this matter, please contact me directly at 202/406-5621.

Sincerely,



Jack L. Johnson, Jr.
Special Agent in Charge

Appendix III: Comments From the Federal Bureau of Investigation



U.S. Department of Justice

Federal Bureau of Investigation

Washington, D.C. 20535

October 22, 2001

Mr. Paul Jones
Director
Justice Issues
General Accounting Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Jones:

Thank you for providing the Department of Justice (Department) with the opportunity to respond to GAO's draft report entitled, "INVESTIGATIVE TECHNIQUES: Federal Agency Views on the Potential Application of 'Brain Fingerprinting'." The Department has asked us to prepare their response since we were the only component of the Department involved in this review.

The report essentially captures the FBI's position concerning the use of "Brain Fingerprinting" but injects the comments of two FBI Special Agents (SA) who in 1992 conducted research with Dr. Lawrence A. Farwell, the developer of this technique. We would therefore like to reiterate our position concerning Dr. Farwell's technology.

The FBI met with Dr. Farwell on two occasions, once in 1993 and once in 1999, as reflected in your report. The FBI concluded, based on its reviews, that the technique has limited applicability and usefulness to FBI investigative and personnel security matters. The evaluation of the validity, reliability, accuracy or applicability in real criminal or intelligence cases of the "Brain Fingerprinting" methods is impossible since the tests alluded to were conducted under sterile mock laboratory conditions absent any real life contamination and cross stimuli. "Brain Fingerprinting" claims to measure "rare, meaningful or noteworthy stimuli" and not truth or deception. Courts have held the selection of probe stimuli is subjective and does not lend credence to truth or deception.

In 1999, we asked Dr. Farwell to provide us with real life examples demonstrating the success of his technology in law enforcement settings. Dr. Farwell advised that he had only one example where his technique was used by law enforcement. Dr. Farwell cited the Julie Helton murder case in which the suspect, Jay Grinder, was confirmed to have committed the murder

Mr. Paul Jones

because he had knowledge of the scene which only the murderer would have. This example was unconvincing to us in that the test was conducted following the prosecution of Defendant Grinder which could have resulted in contamination and cross stimuli. In a real life situation, the test would be used as an investigative tool in an attempt to either identify or eliminate individuals as suspects.

Since that time, Dr. Farwell's technology has been applied in two other criminal matters to our knowledge. The first case, Harrington v. Iowa, is referenced in GAO's report. The second matter was recently reported in a press account. According to the press account, another Iowa man who is serving a life sentence for a 1986 murder, has taken a "Brain Fingerprinting" test and hopes to use the results to overturn his conviction. The Iowa prosecutor (who also represented the State in the Harrington case) claims that recent DNA testing confirms that the man was the murderer. The issue has yet to be adjudicated. We believe that it would be useful to monitor the outcome of this matter in evaluating the validity, reliability, and accuracy of "Brain Fingerprinting".

We would also like to place Dr. Farwell's research in the proper context as it relates to research in other forensic sciences. The FBI conducts research in many aspects of forensic science, some of which prove to be useful to the FBI's mission and some which do not. The FBI conducted a thorough review of Dr. Farwell's research and on two occasions provided him an opportunity to present his findings. In this instance, Dr. Farwell did not conduct research that met the FBI's standards for research, nor did his research demonstrate the usefulness of this technique. As a point of comparison, the FBI conducted years of intense research before DNA technologies were employed as tools in the forensic arsenal.

According to pages 11 and 12 of your report, two FBI agents indicated that they believe that "Brain Fingerprinting" has potential for use in FBI criminal investigations. One of these agents indicated that although it could benefit from continued research and development, the technology is ready for forensic application. We strongly disagree with this statement for the reasons mentioned above, as well as those reflected in your report from other scientific sources.

In conclusion, the report fairly reflects the FBI's belief that this technique has limited applicability and usefulness to FBI investigative and personnel security matters. The FBI continues to support the view that this technique has limited utility. We also think it is important to point out that the rest of the federal community shares the FBI's view that Dr. Farwell's "Brain Fingerprinting" has very limited applicability and usefulness.

**Appendix III: Comments From the Federal
Bureau of Investigation**

Mr. Paul Jones

Again, thank you for the opportunity to review and comment on the draft report. Please contact us if you have questions or desire additional discussion.

Sincerely yours,



John E. Collingwood
Assistant Director
Office of Public and
Congressional Affairs

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