Brain Fingerprinting: Comprehensive Corrections to Rosenfeld in *Scientific Review of Mental Health Practice*[1]

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Introduction

An abbreviated version of this article was published in the *Scientific Review of Mental Health Practice (SRMHP)* in May, 2011.[3] This is a more comprehensive version of the article published in *SRMHP*. This more comprehensive version provides additional details, and in particular provides references to independent sources wherein all of the major facts provided in the abbreviated version of the article can be verified.

This publication focuses on correcting misinformation, misconceptions, and demonstrably false claims in a previous article, Rosenfeld (2005), in *SRMHP*, and Rosenfeld's misuse of that article to support subsequent demonstrably false claims in other publications.

This publication does not provide a comprehensive discussion of the science and technology of brain fingerprinting or the relevant scientific literature. For comprehensive review of the science and technology of brain fingerprinting in the laboratory and the field that includes all of the relevant scientific publications to date, see Farwell (2011a) and Farwell (2012).

Due to overriding security concerns, it has not been possible in the past to publish the details of some of our field research at the CIA, the FBI, the US Navy, and elsewhere. These security concerns have now been resolved, and hence we will shortly be publishing previously unpublished work. We will be publishing six peer-reviewed papers in the coming months on studies that have been completed previously, as well as two invited review papers and several chapters.

The first few sections of the present publication involve simple and readily verifiable facts, and are easily understood by anyone. A full understanding of the latter sections of the present publication, however, requires an understanding of brain fingerprinting science, technology, field applications, and publications reviewed in Farwell (2011a; b). Interested readers may choose to read those publications before reading the latter sections of this publication beginning with the section entitled "Rosenfeld's (2005) *SRMHP* Article."

The purpose of this article is as follows: 1) to provide the readers of *SRMHP* and other interested readers with an accurate basic understanding of the science and technology of brain fingerprinting; 2) to correct demonstrably false and misleading statements made by Rosenfeld (2005) in a previous article in *SRMHP*; 3) to present the facts regarding Rosenfeld's misuse of the *SRMHP* article to support his subsequent false statements and false claims in other forums; and 4) to provide references to sufficient source material to verify all of the above. It is hoped that the readers of *SRMHP* and other interested readers, newly armed with a fundamental understanding of the relevant scientific principles and facts, will be better equipped to evaluate future claims and scientific dialogue regarding brain fingerprinting.

Brain fingerprinting is a scientific technique for detecting concealed information stored in the brain by measuring brainwaves. The author, forensic neuroscientist Lawrence A. Farwell, Ph.D. invented brain fingerprinting in the early 1980s (Farwell and Donchin, 1986, 1991), and later

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http://www.brainwavescience.com/Farwell_Brain_Fingerprinting_Corrections_to_Rosenfeld_Scientific_Review_of_Mental_Health_Practice.pdf

patented it. The author has conducted research and applications of brain fingerprinting at the CIA, the FBI, the US Navy, and elsewhere. He has successfully used brain fingerprinting in the real world in investigating major crimes. Brain fingerprinting, and the author's expert testimony on it, have been ruled admissible in court.

This article will focus on the major misinformation contained in the Rosenfeld (2005) article and Rosenfeld's related false claims and false statements in other forums. Correcting all of the misinformation in the Rosenfeld article, or responding to his many unsupported subjective opinions, would require an excessively long article. We shall focus on Rosenfeld's most salient misstatements of fact. Unlike the Rosenfeld article, this article will not make unsupported subjective judgments, express unsupported opinions, or ascribe motives or thoughts to anyone. The focus of this article will be to state the independently verifiable facts, provide the necessary references to verify them, and allow the reader to reach his or her own judgments and conclusions.

Background and Overview

The Editor in Chief of the *Scientific Review of Mental Health Practice* summarized the raison d'être of the journal as follows: "The primary goal of this interdisciplinary journal is to assist researchers and practitioners across all of the major subdisciplines of mental health with the crucial task of distinguishing scientifically supported from scientifically unsupported claims."

An article in *SRMHP* (Rosenfeld, 2005) addressed the question of what claims were to be subjected to this scrutiny in the journal. The author pointed out that when material purports to be scientific, even when it appears in a non-scientific forum such as a news article or a website, it is appropriate to subject it to such scrutiny.

With this standard in mind, consider the following independently verifiable facts regarding the claims made by clinical psychologist J. Peter Rosenfeld, Ph.D. and his statements regarding his own techniques and regarding forensic neuroscientist Lawrence A. Farwell, Ph.D. and brain fingerprinting, the forensic science technology Farwell invented. This article will provide references to the necessary independent third-party sources to verify all of the below facts.

Overview of Rosenfeld's False Claims, False Statements, and Misuse of his SRMHP Article

Independently verifiable sources specified herein have established that Rosenfeld did the following:

- Rosenfeld conducted laboratory research similar to the brain fingerprinting methods invented and published by Farwell, but failed to follow many of the brain fingerprinting scientific standards that Farwell established and upheld in his research.
- Rosenfeld published results demonstrating that his own alternative techniques have inconsistent accuracy rates, in some cases no better than chance, and overall are far less than the accuracy of brain fingerprinting.
- Rosenfeld falsely stated to the news media that the proven inaccuracy of his own alternative techniques showed that Farwell's brain fingerprinting technique was also inaccurate. After publishing his statements and later checking the facts, the news outlets recognized that Rosenfeld's statements were false and published corrections.

- Rosenfeld published research results demonstrating that his own alternative techniques are susceptible to countermeasures.
- Rosenfeld falsely stated to the news media that the proven susceptibility to countermeasures of his own alternative techniques showed that brain fingerprinting was also susceptible to countermeasures. After publishing his statements and later checking the facts, the news outlets recognized that Rosenfeld's statements were false and published corrections.
- Rosenfeld falsely stated to the news media that Farwell had not published his research in a peer-reviewed journal. After publishing his statements and later checking the facts, the news outlets recognized that Rosenfeld's statements were false and published corrections.
- Rosenfeld later repeated the same and similar false statements about Farwell and brain fingerprinting in *SRMHP*.
- In the same article in *SMRHP*, Rosenfeld falsely attributed to Farwell statements that were in fact made by news reporters and clearly so attributed, and then falsely criticized Farwell for making statements he did not make.
- Rosenfeld used the credibility given by publication in *SRMHP* to his false statements about Farwell and brain fingerprinting as support for subsequent repetitions of the same false statements in other publications and in the news media.
- Rosenfeld made false qualitative claims about the purported value of his techniques in real-world situations. His claims are entirely unsupported by any scientific research or real-world experience. He claimed that his technique could be effectively applied to a "terrorist suspect in custody," whereas in fact no research has been completed on applying his technique in any real-life or field application of any kind, and the accuracy of his technique even in the laboratory has in some studies been no better than chance.
- Rosenfeld made specific false quantitative claims about the accuracy his techniques would achieve when applied in the real world, claims that are directly contradicted by the evidence from his own laboratory.
- Rosenfeld used the article he published in *SRMHP* and his false statements therein as support for subsequent false claims he made regarding the efficacy and accuracy of his techniques and false statements he made about brain fingerprinting. These false claims and statements were published in a scientific journal that specifically cited the *SRMHP* article as support for the same.

We shall present below ample documentation for the above facts, along with references to the necessary third-party sources to verify them. Consider the following statement in light of the above independently verifiable facts.

"(T)he claims…are exaggerated and sometimes misleading" (Rosenfeld, 2005, p. 20).

Clearly, a reasonable person who had independently verified the above demonstrable facts would conclude that this statement definitely applies to Rosenfeld and his claims. What is striking about the above described scenario, however, is that this statement was not made about Rosenfeld.

Were this a statement about Rosenfeld's public claims, it would unquestionably be accurate, as we shall describe in detail below. Surprisingly, however, this is a statement not *about* Rosenfeld but *by* Rosenfeld, and it does not refer to Rosenfeld's false claims at all. He made that statement in his *SRMHP* article (Rosenfeld, 2005) referring -- albeit without foundation in fact, as shall be documented below – to the Brain Fingerprinting Laboratories, Inc. website (www.brainwavescience.com). A review of the independently verifiable facts presented below will reveal that Rosenfeld's statement – like his previous statements described above that were corrected after the relevant publications checked the facts – is unequivocally false and entirely unsupported by the relevant scientific and historical data.

Once the misinformation contained in Rosenfeld's article has been corrected as described below, it will be very clear that the terms "exaggerated" and "misleading" do not apply in the least to any statements by Farwell, and unquestionably do apply to numerous statements made by Rosenfeld in *SRMHP* and elsewhere.

Overview of the Rosenfeld *SRMHP* Article in Context; Roles of Farwell, Richardson, and Rosenfeld

The Rosenfeld (2005) article in *SRMHP* was largely a critique of the Brain Fingerprinting Laboratories, Inc. website, http://www.brainwavescience.com. It included information not generally included in scientific publications, such as material written by reporters in the lay press (which Rosenfeld falsely attributed to Farwell), Rosenfeld's personal email correspondence, and considerable material from the Brain Fingerprinting Laboratories, Inc. website, along with Rosenfeld's subjective opinions and unsupported speculations about the same. The article failed to include extensive information from the same types of sources that would inevitably lead any reasonable reader to different conclusions and generalizations than those advanced by Rosenfeld.

Rosenfeld (2005) summarized the thrust of his article with a classic ad hominem fallacy:

> [J]ust because one person [in context, Farwell] is attempting to commercialize brain-based deception-detection methods prior to completion of needed peer-reviewed research (with independent replication) does not imply that the several serious scientists [in context, including Rosenfeld] who are now seriously pursuing this line of investigation should abandon their efforts. (p. 34)

The fact that Farwell has attempted – and succeeded – in commercializing brain fingerprinting has no bearing on whether other scientists should abandon their efforts. The appropriate factor to consider in deciding whether or not to continue their efforts is whether or not their own efforts are successful and useful, regardless of what Farwell does.

Rosenfeld does not state his criteria for a "serious scientist" who is "seriously" pursuing this line of investigation. One might argue that Farwell meets even very stringent criteria for "serious." In addition to publishing in the premier peer-reviewed scientific journals in both forensic science and psychophysiology (Farwell & Donchin, 1991; Farwell & Smith, 2001), Farwell has accomplished all of the following achievements (none of which Rosenfeld has done):

- Conducted successful research and applications of brain fingerprinting at the CIA, the FBI, and the US Navy;
- Successfully applied brain fingerprinting in real-life situations in the field;
- Successfully used brain fingerprinting in actual criminal cases involving major crimes, including helping to bring serial killer J. B. Grinder to justice;
- Succeeded in attaining admissibility for brain fingerprinting in trial court;
- Testified as an expert witness on brain fingerprinting, and succeeded in having his testimony and stature as an expert admitted by the court;
- Successfully completed major brain fingerprinting contracts with the CIA and also applied brain fingerprinting at the FBI and the US Navy;
- Consistently achieved extremely high accuracy, with no false negatives and no false positives to date; 100% of determinations made were correct; (3% of results overall, constituting 12.5% in one study, were indeterminate but not incorrect).
- Successfully applied brain fingerprinting in detecting a wide variety of information in both laboratory and real-life situations without a single error to date;
- Offered a $100,000 cash reward to any subject who could beat a field brain fingerprinting test, and successfully detected all who attempted to do so;
- Consistently in scientific publications and in over 100 interviews in the national and international press stuck to the facts regarding brain fingerprinting: claimed efficacy only in applications wherein efficacy had already been proven by actual practice (e.g., stated that brain fingerprinting can accurately detect information regarding real crimes when it has already done so; stated that brain fingerprinting meets the standard for admissibility in court when it has been so ruled); and made no numerical claims as to specific accuracy it would achieve in future applications, but rather reported accurately on past accuracy already achieved.

Farwell's colleague and coauthor Drew Richardson, Ph.D. is also "serious" by any reasonable definition. Richardson is the former chief of the FBI's chem-bio-nuclear counterterrorism unit and a 25-year veteran of the FBI Laboratory. He is one of the world's leading experts on counterterrorism as well as one of the world's leading forensic scientists. As a forensic scientist for the FBI, he has examined evidence in over 1,000 cases. He has testified as an expert witness over 100 times in state, federal, and various international courts. He conducted brain fingerprinting research at the FBI with Farwell and worked with Farwell in real-world applications such as the successful use of brain fingerprinting to detect crime-relevant information in the brain of serial killer J. B. Grinder.

Whether or not Rosenfeld and his work qualify as "serious" depends on one's definition. Like Farwell, he has published in peer-reviewed journals (although, unlike Farwell, he has not published in any forensic science journals or conducted or published any real-world research or applications). Rosenfeld's efforts, however, have consisted merely of measuring brainwaves of laboratory experimental subjects who have pretended to steal something or pretended to plan a terrorist attack, testing whether people recognize their own name, attempting to detect "lies" in the laboratory, and the like. He has made no attempt to apply his methods in an actual crime, counterterrorism application, or real-life criminal investigation. In various studies Rosenfeld's published accuracy rates have ranged from below 50% (no better than chance) to over 90%. Up to 50% or more of determinations involving attempted detections of concealed information in some studies have been false negatives. On average Rosenfeld and colleagues have achieved percentages in the 80s. As discussed in detail below, Rosenfeld's techniques have not achieved, even in the laboratory, accuracy rates that would be viable for a technology to be used in the real world, where lives and freedom are at stake.

Farwell's brain fingerprinting has had no false positives and no false negatives; 100% of determinations made have been correct. About 3% of cases overall have been indeterminate, constituting 12.5% in one study. (Note that indeterminate results are not errors.) This is discussed in detail below.

Following the above ad hominem fallacy, Rosenfeld's (2005) article closes with the following truism: "…If it is to be done, it may as well be done well" (p. 34).

The implication, in context, is clearly that the "one scientist" singled out (Farwell) has not "done well," and Rosenfeld has. The relevant facts, which will be presented in some detail below, say otherwise. If "done well" has anything to do with consistently achieving highly accurate results; with success in applying science in the real world; with success in providing value in real criminal investigations; with achieving admissibility in court for one's science, technology, and professional expertise; with successfully and accurately completing government contracts with real-world intelligence agencies requiring an extremely high level of expertise and performance; with truthfully reporting the accuracy of one's methods; or with restricting one's claims regarding real-world use of one's methods to what has actually been proven and accomplished, then of the two, Farwell is the only one who has "done well." Richardson has also "done well" by this definition.

The Rosenfeld article is replete with things that ordinarily are not included in a scientific article, for purported reasons described above. One of the non-standard things that Rosenfeld includes in his article is quotations from the news media. (The fact that Rosenfeld falsely attributes specific statements therein to Farwell will be discussed below.) Rosenfeld gives no indication of his criteria for including particular material from the news media and excluding other material. He excludes extensive material of many kinds that would be useful for any reader to make a well-informed evaluation of brain fingerprinting. Also, he makes no mention of several very relevant and telling statements of his own to the news media.

Rosenfeld's False Statements Have Been Previously Published in the News Media, then Corrected after the Publishers Checked the Facts and Found his Statements To Be False

Rosenfeld has previously made to the news media some of the same false statements about Farwell and brain fingerprinting that he repeats in the article in question.

Some publications have not checked the facts before publishing Rosenfeld's false statements. After first publishing Rosenfeld's false statements and then discovering the actual facts, the publishers have published corrections. Two examples follow.

In a story by the Associated Press (AP), published in the *Fairfield* (Iowa) *Ledger* (Dalbey, 2003), Rosenfeld made the following misstatement of fact:

"Rosenfeld said...Farwell hasn't published his MERMER findings or made them available for peer review."

On June 23, 2003 AP ran the following corrective (Associated Press, 2003):

"In a June 9 story about brain fingerprinting technology, The Associated Press erroneously reported that Lawrence Farwell, inventor of the system, had not published his findings. Farwell wrote about his MERMER testing technology in the *Journal of Forensic Sciences* in 2001."

Note that the *Journal of Forensic Sciences* is one of the leading peer-reviewed journals in the field of forensic science, as described in more detail below.

A similar series of events took place at the Discovery Channel. Rosenfeld made a false statement regarding brain fingerprinting technology and Farwell. Discovery was informed of the facts, checked the facts, and broadcast appropriate corrections.

In a story aired by Discovery Channel Canada on March 14, 2004 (Gilbert & McKeown, 2004a), Rosenfeld made a demonstrably false statement. Referring to brain fingerprinting, he stated that he can teach people to "beat the test" and that his countermeasures "cut the test accuracy in half." Rosenfeld was introduced as a "leading expert."

The truth is that he showed only that his countermeasures are effective against his technique, which according to his own published research has accuracy rates in some studies as low as chance even without countermeasures. He did not show that his countermeasures, or any countermeasures, might be effective against brain fingerprinting. (This is discussed in detail with reference to the relevant scientific literature below.)

The Discovery Channel corrected the false statement by Rosenfeld, and broadcast a revised script in the US and in their subsequent Canadian broadcasts, as follows. Discovery Channel revised the script to make it clear that Rosenfeld's attempts to beat the test are effective against his methods but not against brain fingerprinting. They also removed the phrase in which they referred to him as a "leading expert." The revised script was first broadcast on The Science Channel in the US on March 26, 2004 (Gilbert & McKeown, 2004b). The relevant segments of the revised script are as follows:

> VOICE OVER:
>
> Could Slaughter [a death-row convict tested by Farwell] have outsmarted the technology?
>
> Brainwave researcher Peter Rosenfeld thinks it is possible.
>
> He's testing his own version of the test at Northwestern University.
>
> ROSENFELD:
>
> "We have done research in which we taught just ordinary kids at the university here to beat this test…"
>
> VOICE OVER:

> In other words, Rosenfeld says he can train people to generate P-300 brainwaves…,
>
> This cuts HIS test's accuracy by half.
>
> But Farwell says his brain fingerprinting technology is different, and FAR more accurate.
>
> Farwell has tested all of these cheating methods, and they don't change his results (emphasis [capitalization] in original script).

The central issue: Rosenfeld made false statements in *SRMHP* and misused the *SRMHP* article to support his subsequent false claims in other publications.

There are many inaccuracies, misconceptions, and demonstrably false statements in the Rosenfeld article in question. The present article is a summary of the relevant facts about brain fingerprinting, along with a brief account of only the most glaring of Rosenfeld's false statements and misrepresentations. References are made to available independent sources wherein one can readily verify the correctness of the information below and the falsehood of Rosenfeld's statements.

The central purpose of this article, and the purported purpose of Rosenfeld's (2005) article, is the raison d'être of *SRMHP*: distinguishing scientifically supported from scientifically unsupported claims.

Rosenfeld made false statements regarding Farwell's statements on the availability of brain fingerprinting for field use.

In the *SRMHP* article, Rosenfeld (2005) accused Farwell of making inflated claims regarding the availability of brain fingerprinting for field use. The above quoted "false and misleading" accusation by Rosenfeld referred to this. Rosenfeld took issue with the statement on the brain fingerprinting web site: "The technology [brain fingerprinting] is fully developed and available for application in the field" (p. 34).

In fact, that is an understatement. Brain fingerprinting is not only "ready for application in the field." Farwell already has successfully applied brain fingerprinting in the field. In addition to successfully performing on contracts for the CIA and conducting research at the FBI and the US Navy (e. g., Farwell & Richardson, 2006b), Farwell has successfully applied brain fingerprinting in criminal cases, including one in which it was instrumental in bringing serial killer J. B. Grinder to justice. A trial court in Iowa ruled brain fingerprinting and Farwell's testimony on it admissible as evidence in the Harrington murder case (*Harrington v. State,* 2001). Farwell has successfully used brain fingerprinting in real criminal justice cases, with the extreme difficulties, consequences, motivations, and complications inherent thereto (e.g., Farwell & Richardson 2006b; Farwell, 2008).

Once the misinformation contained in Rosenfeld's article has been corrected as described below, it will be very clear that "false and misleading" does not apply in the least to any statements made by Farwell or to the Brain Fingerprinting Laboratories website, or to any other relevant public statements other than those by Rosenfeld.

Rosenfeld subsequently made false claims, using the *SRMHP* article as support.

The accusation of making false and misleading claims does, however, apply to Rosenfeld. Moreover, he has used the credibility given to his false statements by their publication in *SRMHP* to support his subsequent demonstrably and unequivocally false claims.

Rosenfeld has never attempted to apply his methods in the field, in any situations with any real resemblance to a real criminal investigation, or in fact in any real-life situations at all. Nor has he developed any evidence that his methods might be successful if so applied. Unlike Farwell, however, Rosenfeld himself has made unsubstantiated and false claims to the press about his own brainwave-based detection methods. This shall be described in more detail in light of the relevant science, which is briefly summarized immediately below.

Brief overview of brain fingerprinting methods.

For the purpose of understanding these specific false claims by Rosenfeld, it is only necessary to know a few basic facts about brain fingerprinting experimental protocols, as follows. The brain fingerprinting scientific methods and standards are described in detail elsewhere (e.g., Farwell, 2011a; b).

A brain fingerprinting test involves presenting stimuli, generally in the form or words or phrases presented briefly on a computer screen, and measuring brain responses. When a subject reads a phrase, understands and processes the information contained therein, and recognizes it as significant in context, the brain emits a specific, identifiable brain response known as a P300-MERMER (Farwell & Donchin, 1991; Farwell & Smith, 2001). When a subject reads and processes irrelevant information, or does not read and process information presented, no MERMER occurs.

In a brain fingerprinting test, brainwave responses are measured to three types of stimuli. “Target” stimuli are phrases containing information that the subject knows. “Irrelevant” stimuli are, as the name implies, irrelevant. “Probe” stimuli are phrases containing details about the crime or investigated situation that are known only to the perpetrator and investigators, and not to a subject who has not participated in the crime. (Brain fingerprinting experimental procedures described below ensure that the subject does not recognize the probes for a reason other than participation in the crime.)

For example, a probe might be the murder weapon, such as a knife (if it had not been disclosed publicly and the subject claimed not to know what the murder weapon was). Irrelevant stimuli might be other plausible, but incorrect, murder weapons, such as a pistol and a rifle. A target might be the name of the victim (if it had been publicly released). Experimenters make sure that the subject knows the targets before the test.

All subjects who read and process the stimuli recognize the targets as significant in context. All subjects emit the corresponding P300-MERMER brain response. The irrelevant stimuli are not significant in context, and do not elicit the P300-MERMER response.

A subject without the crime-relevant knowledge does not recognize the probes. All stimuli other than targets appear equally irrelevant. Thus, for a non-knowledgeable subject, probes, like irrelevants, do not elicit a P300-MERMER.

For a subject with the crime-relevant knowledge, the other stimuli consist of irrelevant stimuli and probes. If he reads and processes the probes, he recognizes the probes as being as being significant in the context of the crime. Consequently a knowledgeable subject's brain will emit a P300-MERMER in response to probes. In short, all subjects will emit a P300-MERMER brainwave response in response to targets; no subjects will emit a P300-MERMER in response to irrelevants; and only subjects possessing crime-relevant knowledge will emit a P300-MERMER in response to probes.

The brain fingerprinting data analysis algorithm compares the responses to the three types of stimuli and computes a determination of "information present" (the subject knows the crime-relevant information contained in the probes) or "information absent" (the subject does not know the relevant information).

Brain fingerprinting uses the statistical technique of bootstrapping to determine whether the subject's brain responses to the crime-relevant probe stimuli are more similar to his responses to the known target stimuli (which contain a P300-MERMER) or to the irrelevant stimuli (which do not). If the statistical algorithm returns a high statistical confidence that the probe responses are more similar to the target responses – because both contain a P300-MERMER indicating recognition of the stimuli as relevant in the context of the crime – then the determination is "information present." If the statistical algorithm returns a high statistical confidence that the probe brain responses are more similar to the irrelevant brain responses than to the target responses – because both probes and irrelevants lack the P300-MERMER that the brain responses to the known target stimuli contain – then the determination is "information absent." If the data cannot be classified with a high statistical confidence as either "information present" or "information absent," then the subject is not classified in either category; no classification is made. The outcome is "indeterminate." (Note that "indeterminate" is not an error, but rather an indication that insufficient data were available to make a classification in either direction with a high statistical confidence.)

A brain fingerprinting test, or any other test using brainwaves to detect concealed information, depends critically on the subject reading and processing the stimuli. If a subject simply observes flashes on the screen and does not read and process the stimuli, he will know when a stimulus has been presented, but he will not recognize the probes, and no tell-tale brainwave response will be emitted. A subject who sees a flash on the screen but does not read and process the stimulus will not be detectable by his brainwave responses.

Brain fingerprinting experimental protocols ensure that the subject reads and processes all stimuli, including the probes, as follows. Subjects are required to press one button in response to targets and another button in response to all other stimuli. The stimuli appear in an unpredictable, random order. For each and every stimulus, the subject must read and process the stimulus, decide whether or not it is a target, and press the correct button. The only way the subject can consistently press the correct button for target stimuli (and the other button for all other stimuli) is to read each and every stimulus to determine whether or not it is a target. When it is a target, he will read and process it, recognize it, and emit a P300-MERMER. When it is a probe, he will read and process it. If and only if he knows the relevant knowledge, he will recognize that it is crime-relevant and emit a P300-MERMER. When it is an irrelevant stimulus, he will read and process it, but since it is not relevant or significant in context, he will not emit a P300-MERMER.

Obviously, it is critically important to have a procedure that requires the subject to read and process each and every stimulus, and to prove that he has done so by overt behavior (the correct button press). As discussed below, one of the most important brain fingerprinting scientific standards is that it is necessary to require an overt behavioral task that requires the subject to read and process each and every stimulus and prove behaviorally that he has done so with a button press. This is obviously necessary for any technique that could be used in the field, where subjects cannot be trusted to cooperate except as required by overt behavioral responses.

Rosenfeld falsely claimed that his technique could be effectively used on a "suspected terrorist."

With this understanding, one can evaluate a false claim Rosenfeld made in a news article (Hansen, 2009). Rosenfeld stated:

> "If you had a suspected terrorist in custody and you had some idea what he was planning to do next, you could give him this test," says Rosenfeld…"You wouldn't have to waterboard him, and you'd extract better information out of him, too."
>
> "In general, about one out of 20 subjects will beat the test using countermeasures. But chances are we're going to catch them anyway because their reaction times will give them away," he says. (p. 56).

Rosenfeld's statement that in a real-life criminal investigation "you'd extract better information out of" "a suspected terrorist" using his technique is unsupported by either scientific research or actual experience. Unlike Farwell's brain fingerprinting, Rosenfeld's various methods have never been applied in a single real-life criminal or counterterrorism case.

The Hansen (2009) article referred to and quoted the Rosenfeld's (2005) article in *SRMHP*, and used the credibility given to Rosenfeld's false and misleading statements contained therein to bolster Rosenfeld's subsequent false claims quoted in Hansen. (A discussion of Rosenfeld's false statements about Farwell and brain fingerprinting in the Hansen article is beyond the scope of this article. His false claims about his own techniques in the Hansen article, and his use of the *SRMHP* article to lend unwarranted credibility to him and his claims, however, are relevant.)

In this false claim Rosenfeld is referring to a method he developed called the "complex trial protocol" (Rosenfeld, Labkovsky, Lui, Winograd, Vandenboom, & Chedid, 2008). This technique fails to meet 17 of the 20 brain fingerprinting scientific standards discussed (see Farwell, 2011a; b).

In particular, Rosenfeld et al.'s (2008) technique fails to meet one essential brain fingerprinting scientific standard that is absolutely necessary for any technique to be usable in the field. This standard states that in order to be viable in a field setting, a technique must require an overt behavioral task that requires the subject to recognize and process every stimulus, specifically including the probe stimuli. Any technique that depends on detecting brain responses to assigned tasks that the subject can covertly avoid doing, while performing the necessary overt responses, is clearly unusable in the field.

Rosenfeld and colleagues published several studies using their complex trial protocol, which fails to meet this standard and consequently is unusable in the field (Meixner, Haynes, Winograd, Brown, & Rosenfeld, 2009; Meixner & Rosenfeld, 2010; Meixner & Rosenfeld, in press; Rosenfeld et al., 2008; Rosenfeld & Labkovsky, in press; Rosenfeld, Tang, Meixner, Winograd, & Labkovsky, 2009; Winograd & Rosenfeld, in press). This is a version of Rosenfeld's techniques intended to be more resistant to countermeasures than his other methods.

The complex trial protocol involved the following procedure. Stimuli in the form of words or phrases were presented on a computer screen. Each trial consisted of two stimuli. The first stimulus was either a probe or an irrelevant. The subject made no discrimination between probes and irrelevants, but simply pushed an "I saw it" button to show that he had seen something on the screen. The second stimulus was either a target or a nontarget. The subject was required to read and comprehend the second stimulus and push one of two buttons to indicate whether it was a target or not. The next stimulus was either a probe or an irrelevant, and so on. Experimenters instructed all subjects to cooperate by reading and processing all stimuli, including not only each target/nontarget but also each probe/irrelevant. The cooperative laboratory subjects accommodated the experimenters by doing so.

Experts like Farwell and Richardson, who unlike Rosenfeld actually have expertise and experience in the real world in dealing with terrorists, serial killers, and the like, have discovered not surprisingly that such people do not accommodate scientists the way college students in a mock crime experiment do. Real-world terrorists and serial killers tend to be decidedly unaccommodating people, particularly when their lives are at stake. Farwell, Richardson, and other scientists with real-world field experience are well aware that in field situations with consequences, subjects cannot be trusted to cooperate except as required by overt behavior. Farwell and colleagues have developed their brain fingerprinting techniques accordingly.

Rosenfeld has not. Rosenfeld's protocol could obviously be defeated by an extremely simple and totally effective procedure, as described below. In Rosenfeld's procedure, it is obvious that stimulus presentations wherein a discrimination is made (target/nontarget) alternate one-to-one with stimulus presentations wherein no discrimination is made (probe/irrelevant). Subjects are told this. Subjects are informed that all *probes* are presented only in a position in the totally predictable, alternating sequence where there is *no required discrimination, and consequently no requirement to read, comprehend, and process the stimuli*. Recall that probes are the stimuli containing the crime-relevant knowledge of interest.

Faced with Rosenfeld's method, real-world terrorists or criminals would have no reason to accommodate the experimenters and voluntarily reveal their concealed knowledge. They could simply pay attention to each target/nontarget stimulus presentation, read and comprehend the target or nontarget stimulus, and make the required discrimination and appropriate button-press response. They know from experimental instructions that on the next stimulus presentation no discrimination, comprehension, or processing of the meaning of the stimulus is required. Hence they could *avoid reading or even looking directly at the next stimulus, at the only time where the stimulus might be a crime-relevant probe*. They could simply push the one required "I saw it" button as soon as *anything* appeared on the screen, without processing the stimulus except as a momentary brightening in that general area of the visual field. Then they could read, process, and respond appropriately to the next target/nontarget stimulus, and so on.

Real-world subjects with something to hide can and do effectively follow instructions for the overt button-press task without making the probe-irrelevant discrimination. Thus they show no enhanced P300-MERMER response to the probes. (Nor would there be any slowing of reaction time.) Following each target/nontarget stimulus, they would not read or process the next (probe/irrelevant) stimulus. Following each *unread* probe/irrelevant stimulus presentation, they would read the next stimulus and make the required target/nontarget distinction, and so on.

Rosenfeld and colleagues (e.g., Rosenfeld et al., 2008) instructed their subjects not to take advantage of this fatal flaw. Their laboratory subjects were accommodating. They read and processed the probe stimuli, even though there was no need to do so in order to follow the instructions for overt behavior. Consequently they exhibited large P300-MERMERs in response to probes and were detectable even by this fatally flawed procedure.

In a field situation, covertly uncooperative subjects do not accommodate the experimenters in this way, and are undetectable by either brainwaves or behavior. The above procedure to beat Rosenfeld's test is so obvious that it would not even have to be taught as a countermeasure. It is simply what a knowledgeable and/or reasonably intelligent criminal or terrorist can be expected to do. (Rosenfeld and colleagues taught some subjects a different, complicated countermeasure that had limited effectiveness.)

In the only study in which the "complex trial protocol" was applied in the detection of real-world information in motivated subjects (Farwell et al., 2013), it had 0% accuracy – much worse than chance – because all subjects figured out on their own the simple behavior necessary to beat the test as described above.

This same simple procedure could obviously defeat Rosenfeld's revised protocol wherein subjects pressed one of several buttons randomly in response to probes and irrelevants, without distinguishing probes from irrelevants (Rosenfeld & Labkovsky, in press). When subjects were required to press one of five buttons, each assigned to a specific irrelevant stimulus, accuracy was reduced to near chance levels (Meixner et al., 2009). Other recent studies by Rosenfeld and colleagues (Meixner & Rosenfeld, 2010; Meixner & Rosenfeld, in press; Rosenfeld & Labkovsky, in press) showed higher accuracy rates but suffered from the same fatal flaw in experimental procedures.

Rosenfeld's complex trial protocol may be of use in investigating brain responses and information processing in cooperative subjects in the laboratory. The fatal flaw in experimental procedures, however, makes it unusable in field situations with potentially covertly uncooperative subjects and real consequences, despite Rosenfeld's false claims to the contrary.

Moreover, as quoted above, Rosenfeld (2005) falsely accuses Farwell of making claims "prior to completion of needed peer-reviewed research (*with independent replication* [*italics added*])" (p. 34). As will be described in detail below, Farwell's brain fingerprinting methods have been published in peer-reviewed journals (e.g., Farwell & Donchin, 1991; Farwell & Smith, 2001) and replicated in other laboratories (e.g., Allen & Iacono, 1997; Allen, Iacono, & Danielson, 1992). Scientists who have followed proper brain fingerprinting scientific protocols have achieved high accuracy rates similar to that of Farwell's brain fingerprinting (e.g., Allen & Iacono; Allen, Iacono, & Danielson). Once again, Rosenfeld's accusations apply not to Farwell but to Rosenfeld himself. His complex trial protocol, the technique that Rosenfeld falsely claimed would be applicable in testing a real-world terrorist, is not only unusable in the field as explained above, but also has never achieved "independent replication" in any laboratory. On the contrary, as described above, the only independent study on the complex trial protocol demonstrated that it has 0% accuracy in real-world situations with motivated subjects.

The complex trial protocol also suffers from a second fatal flaw, one involving misuse of statistics. Recall that the brain fingerprinting statistical algorithm uses bootstrapping to classify the brain responses to crime-relevant probe stimuli as more similar to the known target responses (which contain a P300-MERMER) or more similar to the irrelevant responses (which do not). Bootstrapping computes a statistical confidence for each "information present" or "information absent" determination. If a classification cannot be made in either direction with a high statistical confidence, the outcome is "indeterminate."

The complex trial protocol uses bootstrapping in a different way. It ignores responses to the target stimuli, and computes a probability that the probe responses contain a "larger" P300 than the irrelevant responses. If the probability that the probe responses are "larger" than the irrelevant responses is greater than a criterion (usually 90%), then the subject is classified as information present (for which Rosenfeld uses the misnomer "guilty"). If the probability is less than 90% that the probe responses are "larger" than the irrelevant responses, then the subject is classified as information absent (or "innocent"). *This means that a subject whose data provide up to an 89% probability that information present ("innocent") would be the correct classification are classified as information absent ("guilty").* An 89% probability that an information-present classification is correct is the same as an 11% probability that an information-absent classification is correct (100% - 89% = 11%). In other words, the complex trial protocol produces information-absent/"innocent" determinations that have as low as an 11% probability – much worse than chance – of being correct. Rosenfeld's publications have reported subjects misclassified as "innocent" when the probability according to the statistics reported was as high as 86% that this classification was incorrect and the opposite classification would have been correct.[4]

Obviously, it is not viable to present in any non-trivial real-world application evidence arising from the complex trial protocol, which – according to the statistics used in the procedure itself – has as low as an 11% probability of being correct.

This fatal statistical flaw cannot be ameliorated by simply changing the statistical confidence criterion, for the following reason. The statistics computed return a probability that the probe responses contain a "larger" P300 than the irrelevant responses. If the subject lacks knowledge of the information contained in the crime-relevant probes, then on average the probe responses will be the same size as the irrelevant responses – both lacking a P300. Statistically, the expected value of a statistic to determine if the probe responses are larger than the irrelevant responses will be 50%. Thus, if the technique works optimally for information-absent subjects, on average the confidence that the probe responses are larger (or not larger) than the irrelevant responses will be 50%. In other words, the average statistical confidence for an "innocent" determination, under optimal conditions, will be 50%. If in fact the subject is information absent

[4] For example, Meixner and Rosenfeld (2010), Table 2, page 63, GNO condition misclassified subject 10 as "innocent " when the probability that a "guilty" classification was correct was 86%.

and there are no differences between probe and irrelevant brain responses, and if the procedure works optimally, then the statistical procedure will return the conclusion that the probe responses are not larger than the irrelevant responses with an average statistical confidence of 50%. This means that the complex trial protocol, when it works optimally, and even when the determinations are correct, will produce the same statistical confidence for information-absent/"innocent" determinations as a coin flip: 50%.

On average, half of the subjects classified as "innocent" will be classified with greater than a 50% statistical probability that that classification is correct. Half of the subjects will be classified with less than 50% probability that the classification given by the complex trial protocol is correct, and greater than 50% probability that the opposite classification would have been correct.

Changing the criterion cutoff for the classification will change the proportion of subjects who are misclassified in each direction, but will not result in a viable statistical confidence for information-absent/"innocent" determinations. Even introducing an indeterminate range will not solve this fatal flaw, because the information-absent/"innocent" classifications will still have an expected value of approximately a 50% confidence.

Obviously, the complex trial protocol experimental method, which results on average in no higher confidence for information-absent/"innocent" determinations than a coin flip – no better than chance – could not be used in the real world. A viable technique that affects peoples' lives and freedom must be able to demonstrate greater than a 50% statistical probability of being correct.

It comes as no surprise that in some of the experiments reported by Rosenfeld and colleagues (described in more detail below) the accuracy of determinations produced by the complex trial protocol (as well as the statistical confidence for these determinations) is no better than chance.

In summary, Rosenfeld's statement that "you'd extract better information out of" "a suspected terrorist in custody" using his technique is not only unsupported by any scientific data. It is also contrary to scientific principles, logic, common sense, and the experience of experts such as Farwell and Richardson who have real-world experience in dealing with such people.

If the two fatal flaws in Rosenfeld's technique were not so obvious, his false claims could pose a national security risk. If a national security or law enforcement agency actually believed Rosenfeld's false claims – which they might have if his technique were not so obviously unusable in a real-life situation – a national security or law enforcement might agency have attempted to use Rosenfeld's technique in the real world, with disastrous consequences. Fortunately, no national security or law enforcement agency has found Rosenfeld's false claims to be credible enough to do so.

Rosenfeld made specific, numerical, demonstrably false claims regarding the accuracy of his technique.

In addition to his false claims regarding applicability in the real world, Rosenfeld claimed a much higher accuracy rate in the field than his technique has achieved even in highly controlled and artificial laboratory conditions. As noted above, Rosenfeld stated:

> "If you had a suspected terrorist in custody and you had some idea what he was planning to do next, you could give him this test," says Rosenfeld…"You wouldn't have to waterboard him, and you'd extract better information out of him, too."
>
> "In general, about one out of 20 subjects will beat the test using countermeasures. But chances are we're going to catch them anyway because their reaction times will give them away," he says. (Hansen, 2009, p. 56).

Rosenfeld made a specific numerical claim about the projected accuracy of his technique in the field (where it has never been used), a claim that would not have been true even if he had been referring only to his laboratory tests. In the above cited quotation, Rosenfeld claims his technique would achieve 95% accuracy in detecting terrorists when they practice countermeasures, and mentions no possibility of any errors at all except those brought about by countermeasures. He claims 5% false negatives with countermeasures and strongly implies 0% false negatives without countermeasures.

He also says that even for the 5% of subjects who beat the system with countermeasures, "chances are we're going to catch them anyway" with reaction time measurements. This clearly is a claim that his technique can be expected to achieve a false negative rate even lower than 5% when reaction times as well as brainwaves are considered.

This amounts to a claim of over 95% accuracy with countermeasures and a strong implication of 100% accuracy without countermeasures in detecting concealed information. (His claim does not address detecting "innocent" subjects who do not know the relevant information, or false-positive errors in failing to detect such subjects.)

Aside from the facts that Rosenfeld has never attempted a field or real-world application of his technique, and that his technique is unusable in the field due to two fatal flaws in the experimental procedure as explained above, the actual results of Rosenfeld's experiments with this technique even in highly contrived laboratory settings are nowhere near the numbers he claims. Rosenfeld's detection rates in laboratory experiments with this technique (Meixner et al., 2009; Meixner & Rosenfeld, 2010; Meixner & Rosenfeld, in press; Rosenfeld et al., 2008; Rosenfeld et al., 2009; Rosenfeld & Labkovsky, in press; Winograd & Rosenfeld, in press) for subjects who have the relevant knowledge have ranged from 53% (8 of 15 subjects) (Meixner et al.) to 100% (12 of 12 subjects) (Meixner & Rosenfeld, in press) and averaged approximately 87% without countermeasures. With countermeasures, accuracy has ranged from 36% (Meixner et al.) to 100% (Meixner & Rosenfeld, in press) and averaged approximately 71%. In some cases the inclusion reaction-time analysis has resulted in detection of subjects otherwise undetected. For example, using their preferred analysis method Rosenfeld et al. (2008) detected 63% of countermeasure subjects with brainwaves and 87% by including reaction times.

His own published data show that Rosenfeld's claim of over 95% accuracy with countermeasures and strong implication of 100% accuracy without countermeasures is false. His claim would have been false even if it had been only about laboratory studies and not application to "a terrorist in custody" in the real world. Nor is there any evidence in any of his publications or anywhere else that even the moderate accuracy rates obtained (albeit inconsistently) in Rosenfeld's highly contrived laboratory conditions would be obtained if his procedures were attempted on a "suspected terrorist in custody" or in any real application.

Rosenfeld (2005) made another comment (purportedly about the Brain Fingerprinting Laboratories website) that rings true as applied to Rosenfeld himself. Rosenfeld's false claim (Hansen, 2009) about the results that could be obtained with his system on a real-world terrorist is (to use his words) "perhaps most charitably, viewed as florid advertising copy" (Rosenfeld, p. 34).

Rosenfeld's false claims of accuracy were not restricted to florid statements to reporters, however. His false claims extended to the realm of scientific journals as well. In an article in *Psychophysiology*, Rosenfeld et al. (2008) cited Rosenfeld's (2005) *SRMHP* article, and the false information contained therein, in support of a false claim that his technique is "more accurate" than previously published methods for detecting concealed information (p. 917). (Brain fingerprinting is obviously a previously published method.) It is false on the face of it to claim that Rosenfeld's technique, which has had up to nearly 50% false negatives in some studies and averaged about 13% false negatives, is more accurate than brain fingerprinting, which has never had a false negative (or a false positive). This is discussed in detail below in the context of more detailed discussions of accuracy rates, statistics, publications, and countermeasures.

Farwell, by contrast, in over 100 interviews published in the national and international press, has never once predicted a specific percentage accuracy rate for brain fingerprinting. Even when pressed, he has refused even to predict that brain fingerprinting will achieve the specific numerical accuracy (100%; see below discussion) in future real-world cases that it has in past real-world cases (*Harrington v. State*, 2001; Moenssens, 2002; Roberts, 2007). Farwell's only discussions of specific numbers with respect to accuracy have to been to report accurately the results already achieved in the past.

In order to understand the factual and scientific basis for correcting many of the other false statements and misconceptions in Rosenfeld's (2005) *SRMHP* article described below, it is first necessary to understand the relevant science and technology. For a review of the science of brain fingerprinting in the laboratory and the field, including all of the published research on brain fingerprinting and all of the similar (and dissimilar) techniques that have arisen based on the original brain fingerprinting science, see Farwell (2011a; b). In the interest of brevity, such a review is not reproduced here. The following sections assume, however, that the reader already has a comprehensive understanding of the science and technology of brain fingerprinting in the laboratory and the field as described in those publication and others by Farwell and colleagues, and is familiar with the other relevant published research, also reviewed therein.

Rosenfeld's (2005) *SRMHP* Article

Rosenfeld's (2005) False Statements and Subsequent False Claims Based Thereon

Rosenfeld made false statements regarding Farwell's scientific publications in peer-reviewed journals.

In his *SRMHP* article, Rosenfeld (2005) made demonstrably false statements regarding Farwell's scientific publications. Referring to the paper authored by Farwell and FBI scientist Sharon Smith (Farwell & Smith, 2001), Rosenfeld stated: "this later paper appeared in an outlet which is not a peer-reviewed or leading journal in psychology, neuroscience, or psychophysiology… it is unlikely that this report would have appeared in a major journal" (p. 23).

The Farwell and Smith (2001) paper was published in the *Journal of Forensic Sciences*, one of the leading peer-reviewed journals in forensic science. (As noted above, Rosenfeld has misinformed the press on this subject, stating that the Farwell and Smith paper on the MERMER was not published in any peer-reviewed journal. When the AP checked their facts after publishing Rosenfeld's false statement, they published a correction correctly identifying the *Journal of Forensic Sciences* as the peer-reviewed publication where the Farwell and Smith paper was published.)

Rosenfeld's (2005) first statement above has so many qualifiers ("psychology, neuroscience, or psychophysiology") that it might not technically be totally false, but it is certainly misleading. This would be equivalent to saying Rosenfeld has never published anything in a peer-reviewed or major journal in biology or forensic science, without mentioning his relevant publications in other relevant peer-reviewed journals.

Rosenfeld's second statement is unequivocally false. It is not "unlikely" that the Farwell and Smith forensic-science paper would be published in a "major journal," because it has been published in one of the most major journals in forensic science.

In dismissing the *Journal of Forensic Sciences*, Rosenfeld (2005) stated, "(T)here has been only one serious publication (on brain fingerprinting)" (p. 34), namely the seminal paper on the subject by Farwell and Donchin (1991). Just as he does not define a "serious" scientist, he provides no hint of the criteria by which he dismisses the *Journal of Forensic Sciences* as not being "serious" or "major."

In fact, the *Journal of Forensic Sciences* is by any reasonable standard both "serious" and "major" among forensic science journals. It is the official journal of the American Academy of Forensic Sciences. Its impact factor of 1.524 is among the highest for forensic science journals. This impact factor compares favorably with the impact factor of 0.884 for the journal where Rosenfeld published his first two articles on EEG-based detection methods, the *International Journal of Neuroscience.*

Rosenfeld used his false and misleading statements in his *SRMHP* article to support his subsequent false claims for the accuracy of his alternative technique.

Rosenfeld used these false statements he made in *SRMHP* (Rosenfeld, 2005) to lend false credibility to his subsequent false claims of accuracy for his technique. In an article in *Psychophysiology*, Rosenfeld falsely claims that his "complex trial protocol," discussed above with reference to the fatal flaws that make it unusable in the field, is more accurate and resistant to countermeasures than brain fingerprinting and other techniques. Rosenfeld et al. (2008) stated:

> The studies reported here suggest that the CTP [Rosenfeld's complex trial protocol] is more accurate and resistant to CMs [countermeasures] than previously published ERP- based studies in detecting concealed information. (We do not include here more recent reports and claims of Farwell, e.g., Farwell & Smith, 2001, and on his web site called ''Brain Fingerprinting'' for reasons detailed in [Rosenfeld (2005)]). (p. 917).

On the face of it, this statement is clearly false with respect to accuracy. (It is also false with respect to countermeasures, as discussed below.) Brain fingerprinting has never resulted in a false negative or a false positive. Rosenfeld's complex trial protocol has resulted in as many as 47% false negatives in some conditions (Meixner et al., 2009), even without countermeasures, and has averaged about 19% false negative errors (see details below).

In the only study in which it was applied to real-world events in the lives of motivated subjects who actually had something to hide, the "complex trial protocol" had 0% accuracy – much worse than chance (Farwell et al., 2013). This is because all subjects figured out on their own how the simple behavior necessary to consistently beat the test and produce a false negative result, and all did so without even being trained in countermeasures.

Let us examine, however, whether there might be some way of looking at some portion of the data that would make Rosenfeld's claim appear to be true.

In the real world, what accuracy means it this: we are testing a suspected terrorist in custody or an accused murder suspect in a maximum-security prison, as Farwell has done in the real world. Hypothetically, then, we have conducted a test on a terrorist with a brainwave-based information detection technique. The technique concludes that he does not know the incriminating information he is accused of knowing. How confident can we be of this result? This question can be phrased more precisely as: how often has this same test returned an error in the past?

If we have tested him with brain fingerprinting, the answer is simple and unambiguous: brain fingerprinting has never resulted in a false negative (or a false positive); 100% of brain fingerprinting determinations made have been correct, both in the laboratory and in the field. We can be highly confident that this new result is accurate.

Note that we cannot say, and Farwell has never said or implied (Moenssens, 2002), that we are 100% certain, or that the future determinations will necessarily be 100% accurate just because past brain fingerprinting determinations have been 100% accurate.

If we have tested him with Rosenfeld et al.'s (2008) technique, an information-absent ("innocent") response can mean one of two things: 1) he does not know the information tested; or 2) he is intelligent and/or knowledgeable enough to see the fatal flaw in the procedure (see above discussion), and unaccommodating enough to take advantage of it to pass the test. There is no way to distinguish between these two situations. As discussed above, Rosenfeld's technique is obviously unusable in the field for this reason, and has never been used in the field.

Rosenfeld's claim is totally unsupported by scientific research or real-world experience, and in fact is unequivocally false, if applied to real-world situations. (This is discussed in more detail in the section entitled "Rosenfeld falsely claimed that his technique could be effectively used on a 'suspected terrorist.'")

What if we restrict our considerations to laboratory tests? To set up the worst possible case for brain fingerprinting, and therefore the best opportunity to support Rosenfeld's claim, let us restrict our considerations to the one brain fingerprinting study that Rosenfeld considers "serious," which is the only brain fingerprinting study of any kind wherein there were any indeterminate results (Farwell & Donchin, 1991). (The analysis included only the P300, and not the full P300-MERMER, in the computations.)

The answer is still the same. In Farwell and Donchin (1991), brain fingerprinting resulted in no false positives and no false negatives; 100% of determinations were accurate. We can still be highly confident that our new determination is accurate.

Compare this with Rosenfeld's technique as tested in the laboratory (with accommodating subjects, as discussed above). Rosenfeld and colleagues' detection rates without countermeasures for subjects with the relevant knowledge have ranged from 53% (8 of 15 subjects) (Meixner et al., 2009) to 100% (12 of 12 subjects) (Meixner & Rosenfeld, in press) and averaged approximately 87% without countermeasures, or 13% false negatives (Meixner et al., 2009; Meixner & Rosenfeld, 2010; Meixner & Rosenfeld, in press; Rosenfeld et al., 2008, 2009; Rosenfeld & Labkovsky, in press; Winograd & Rosenfeld, in press). With countermeasures, accuracy has ranged from 36% (Meixner et al., 2009) (64% false negatives, lower than chance accuracy) to 100% (Meixner & Rosenfeld, in press) and averaged approximately 71%. Overall, with and without countermeasures, false negatives have averaged approximately 19% (81% accuracy). Overall, including also true and false positives, false negative and false positive errors have been approximately 15% (85% accuracy). (Rosenfeld and colleagues' studies did not have an indeterminate category of results, as discussed above.)

Hypothetically, we have a subject in a laboratory study who may have participated in a mock crime. How confident can we be that a new determination made today with Rosenfeld et al.'s (2008) technique is correct? We can pick any of the above average numbers. None of them approach, let alone exceed, the brain fingerprinting's record of no false negatives, no false positives, 100% correct determinations. Rosenfeld's claim is false and unsupported by the scientific data, even if we use the worst possible case for brain fingerprinting and ignore all other brain fingerprinting results.

Could some alternative statistical procedure provide plausible support for Rosenfeld's claim? Perhaps we can find a way to use the indeterminates in Farwell and Donchin (1991) to support the claim. Recall that in the above discussion of bootstrapping we showed that indeterminates are a vital and necessary feature of correct use of the bootstrapping statistical technique in brain fingerprinting.

Farwell and Donchin (1991) reported 12.5% indeterminates in the laboratory. There is no way to make all of the indeterminates turn into some combination of false positive and false negative errors. A glance at Figure 2 of Farwell and Donchin reveals that this would be a mathematical impossibility: any possible criterion we may choose to make some indeterminates into errors will also result in at least some of the indeterminates becoming correct determinations.

If we are willing to misuse statistics, however, we can make some of the indeterminates appear to be false negatives or false positives. To do this we can re-analyze the data and force a (non-indeterminate) determination in every case by establishing a single, reasonable criterion for information present, and classifying as information absent all subjects who fail to meet this criterion. (Alternatively, and equally illogically, we could set a single, reasonable criterion for information absent, and classify all subjects whose data failed to meet this criterion as information present.)

As discussed above, this would be contrary to logic, mathematical probability, common sense, and proper use of statistics, not to mention the violence it would do to human rights and national security if applied in the real world. It would involve the untenable practice of classifying subjects in a category where there is up to a 90% probability that the classification is an error. Since Rosenfeld has advocated and used this untenable procedure, however, we shall examine the result of applying it to Farwell and Donchin's (1991) data.

As can be seen from Figure 2 of Farwell and Donchin (1991), if we set our information-present criterion at the usual 90%, but fail to set a separate criterion for information absent determinations, and classify all subjects that fall short of the information-present criterion as information absent, we will have two false negatives and no false positives. With 40 subjects, this equals 95% accuracy.

In fact, we could pick any other information-present criterion from the usual 90% confidence that the classification is correct down to as low as 60% confidence, and the result would still be 95% accuracy. (Note that no one has ever suggested or used an information-present criterion as low as 60% bootstrap statistical confidence. Nor would it make any sense to do so: a classification of information present with a statistical confidence of less than 60% would not be defensible.)

In short, if we are willing to misuse statistics in order to make the accuracy of brain fingerprinting appear as low as possible, and if we restrict our data set to the worst possible case, we can make brain fingerprinting appear to be only 95% accurate.

Compare this with the worst case for Rosenfeld et al.'s (2008) technique (54% accuracy without countermeasures), or with any of the overall average results for this technique listed above – 71%, 81%, 85%, or 87%. All of these are considerably less than 95%. The bottom line is that no amount of artificial selection of data sets or sleight of hand with statistics can disguise the fact that Rosenfeld's claim that his technique is "more accurate" is false (Rosenfeld et al., 2008). Any way you look at it, Rosenfeld's claim is not only unsupported by the scientific data, it is directly contradicted by the scientific data.

As is the case with Rosenfeld's false claims to the press discussed above, Rosenfeld's use of the misinformation contained in his *SRMHP* article and the credibility gained by publication therein to support his subsequent false claim in *Psychophysiology* (Rosenfeld et al., 2008) is to no avail. His subsequent claim is unequivocally and demonstrably false by any reasonable standard.

Rosenfeld falsely attributed the inaccuracy of other, non-brain-fingerprinting techniques to brain fingerprinting.

Rosenfeld asked, "Regarding P300-based GKT studies from independent laboratories, how does the BF [brain fingerprinting] method fare?" (p. 25).

As an answer, he discussed several non-brain fingerprinting studies that reported low accuracy rates, including one of his own, Rosenfeld et al. (2004). As discussed above, that study was not a test of "how does the BF method fare?" It failed to meet 17 of the 20 brain fingerprinting scientific standards (see Farwell, 2011a; b). He also cited a study published by Mertens et al. (2003) that failed to meet many of the brain fingerprinting standards and reported low accuracy rates. Both of these studies are discussed extensively Farwell (2012) as examples of several of the most common errors and errors that have resulted in the greatest decrements and accuracy.

The Mertens et al. (2003) study, which Rosenfeld (2005) apparently found “serious” enough and sufficiently well published to cite and consider in his arguments, was published in abstract form in *Psychophysiology*. Rosenfeld did not cite or consider several studies published by Farwell and colleagues in the same form in the same journal (Farwell & Donchin, 1986, 1988b; Farwell, 1992b). Unlike the Mertens et al. (2003) study, these studies actually tested brain fingerprinting. All of these brain fingerprinting studies reported 100% accurate determinations, with no false positives, no false negatives, and no indeterminates.

Rosenfeld cited Miyake et al. (1993), another study discussed herein and in Farwell (2012) as a prime example of the negative consequences of failure to meet the brain fingerprinting scientific standards. This study is further discussed below and in Appendix 1.

There is nothing wrong with conducting studies that attempt to detect concealed information using event-related brain potentials and using different techniques from brain fingerprinting, as these experimenters have done. There is nothing wrong with obtaining inaccurate results as a result of the (non-brain fingerprinting) scientific procedures followed. There is nothing wrong with reporting these results. The only valid scientific conclusion that can be drawn, however, is that these alternative, non-brain fingerprinting techniques are inaccurate. These data do not support Rosenfeld’s (2005) conclusion that brain fingerprinting must also be inaccurate.

Testing other techniques that fail to meet a majority of the brain fingerprinting scientific standards does not tell us “how does the BF method fare?” It tells us how these alternative, non-brain fingerprinting methods fare. Rosenfeld’s (2005) answering his question regarding the accuracy of “the BF [brain fingerprinting] technique” with a discussion of the inaccuracy of alternative, non-brain fingerprinting techniques is misleading at best.

Rosenfeld made demonstrably false statements regarding Farwell’s sworn expert testimony in the Harrington case.

Rosenfeld cited a study conducted by Miyake et al. (1993) in Japan as purported evidence of the inaccuracy of brain fingerprinting. As discussed below, an examination of the relevant facts reveals that the Miyake et al. study was fundamentally different from brain fingerprinting, used fundamentally different methods, and did not meet minimal scientific standards necessary for accurate or valid results. The fact that Miyake et al. obtained highly inaccurate results was due to the different procedures they followed and to their failure to implement standard or adequate scientific methods. This in no way reflects on the accuracy of the procedures and scientific protocols used in brain fingerprinting.

In this context, Rosenfeld (2005) falsely accused Farwell of not telling the truth, the whole truth, and nothing but the truth while under oath when Farwell testified as an expert witness. This is a serious accusation (by the usual definition of the word “serious”). An examination of the relevant science and testimony reveals that Rosenfeld’s accusation is without any foundation in fact.

Rosenfeld quoted Farwell’s sworn testimony on brain fingerprinting science in the Harrington case (*Harrington v. State*, 2001). This was a murder trial wherein brain fingerprinting science and Farwell’s testimony on it were ruled admissible, as discussed above. Rosenfeld (2005) then characterized Farwell’s testimony as “erroneous and misleading” (p. 25). The independently verifiable facts, however, show that Rosenfeld's characterization of Farwell's testimony is false. The historical and scientific facts support Farwell's testimony as being truthful and accurate.

The subject at hand was the article by Miyake et al. (1993). The prosecution attempted to present the article as evidence in the Harrington case, and questioned Farwell about it. Farwell testified that their methods were fundamentally different from brain fingerprinting and did not meet the necessary scientific standards. The opposing expert witness did not disagree. The court did not accept the Miyake et al. (1993) article into evidence.

Rosenfeld (2005) quoted the following testimony by Farwell, "They [Miyake et al. (1993)] recorded from Cz, so I don't know what they were measuring . . . it appears they were doing something that was in no way related to what we did." (p. 25).

Farwell's further testimony (which Rosenfeld did not quote) cited specific scientific reasons why what Miyake et al. (1993) were doing was "fundamentally different from what I do [brain fingerprinting]" (*Harrington v. State*, p. 127) and did not meet the relevant scientific standards.

Miyake et al. (1993) failed to meet 18 of the 20 brain fingerprinting scientific standards (see Farwell, 2012). Moreover, the experimenters failed to implement data collection, artifact rejection, and data analysis procedures that meet the universal standards met by other laboratories in the field of event-related brain potential research.

They measured P300 from the wrong scalp location. Their classifications were based not on any mathematical algorithm but on subjective judgments by the operators. They failed to use well-known standard methods, or any method, for artifact rejection or correction, resulting in inadequate data for accurate analysis or conclusions. Their timing parameters were outside the range used in other laboratories in event-related potential research. They used an insufficient number of trials. They attempted to detect lying, rather than information. These errors resulted in an exceptionally low accuracy rate. Only 65% of their determinations were correct, with 17% indeterminate.

Farwell clearly pointed out in his testimony (*Harrington v. State*, 2001) that the Miyake et al. (1993) study has numerous serious methodological flaws, and numerous differences from brain fingerprinting. This study is discussed in more detail in Appendix 1, "Differences between Miyake et al. (1993) and Farwell's Brain Fingerprinting."

In view of these relevant facts, Farwell's testimony was truthful and accurate. Rosenfeld's accusations to the contrary are false.

Rosenfeld (2005) further stated, "had there been a P300 expert present, he/she could have retorted…[to Farwell's testimony that Miyake et al.'s (1993) methods were different from brain fingerprinting]" (p. 25). The implication is that there was no P300 expert present. Aside from being a defamatory comment on Farwell's expertise on P300 – which was recognized by the court, by the other two expert witnesses on both sides, and by the scientific community wherein his research has been published – this comment fails to recognize the presence in the courtroom of two other expert witnesses. Emanuel Donchin and William Iacono are without question two of the top P300 experts in the world.

Donchin testified after Farwell, on the opposite side (prosecution). He did not dispute Farwell's testimony on Miyake et al. (1993) or the court's refusal to admit the Miyake et al. article as evidence. If Farwell had been less than completely truthful, or if there had been any scientific or legal validity to a challenge of Farwell's testimony on Miyake et al., it could have and undoubtedly would have been pursued by the prosecution and the opposing expert witness when he took the stand.

Rosenfeld falsely described Farwell's peer-reviewed publications and falsely criticized Farwell's expert witness testimony on that basis.

Rosenfeld (2005) stated: "In any case, neither Farwell and Donchin (1991) nor Farwell and Smith (2001) provide support for this retrospective use of BF as in the Harrington case, since these studies tested for recently acquired information by well practiced subjects. There is, in fact, no published, peer reviewed, scientific evidence whatsoever supporting this retrospective testing as was done in the Harrington case" (p. 31).

(Rosenfeld apparently uses the term "retrospective" to mean testing for information regarding real-life events that occurred in the subject's life, as opposed to information that the subject acquired in the laboratory through a knowledge-imparting procedure such as a mock crime. The standard and more accurate terms that other authors use to describe such tests are "field test," "real-life test," and "real-world test.")

Rosenfeld's (2005, p. 31) two sentences quoted immediately above contain several demonstrably false statements, as follows.

The Farwell and Smith (2001) study was specifically designed to use brain fingerprinting to detect information regarding real-life events in the lives of FBI agents, events that in some cases took place many years previously. Contrary to Rosenfeld's (2005) statements, the information was not "recently acquired," nor were the subjects "well practiced." Farwell and Smith clearly stated these facts:

> One person in each pair (person A) was interviewed about details of the personal history and life experiences of the other (person B). Stimuli relevant to a particular real-life event were developed from interview material…In each case, prior to the test, the knowledgeable subject did not discuss the information to be detected with the informer. On the day of the testing, all subjects were instructed to behave as if they knew nothing of the events investigated and to refrain from saying or doing anything that would reveal any relevant knowledge they might have to the researchers. (p. 138).

Farwell also clearly described this experiment in his testimony in the Harrington case (*Harrington v. State*, 2001). At the time, the Farwell and Smith (2001) article had been accepted for publication in the *Journal of Forensic Sciences*, a major peer-reviewed forensic science journal, as discussed above. It had not yet been printed, however. Farwell testified as follows (*Harrington v. State*, 2001, p. 12).

A Yes. There is another study that I am publishing in the
Journal of Forensic Sciences with Sharon Smith of the FBI.

She is an instructor at the FBI Academy in Quantico. This was very similar to the study that we did initially on the students. Again, we had pairs of individuals, and in each pair, one of the individuals had committed some kind of an activity. These weren't crimes. They were just real life activities that they had engaged in, and one of them had not. In each case as before, we had one person who we were testing for knowledge of an event, and then we got that information from somebody else, so we recruit a subject and somebody who knew that subject, and we had permission then to find out about that person's past from the other person. The person who knew the subject would tell us, "Okay, here is a particular event that the person participated in some years ago, and here are the details about that event." We used those details, and what we found was that in every case, when we flashed those particular details mixed in with the irrelevant items on a screen, the individual would recognize them, they would emit a P300 and we could tell with a high statistical confidence which event people participated in, and which ones they hadn't.

Farwell and Donchin (1991) conducted two experiments. “Experiment 1” was a mock espionage scenario. “Experiment 2” was essentially the same as the Farwell and Smith (2001) study on real-life events in the lives of FBI agents. Farwell referred to the former in the above trial transcript (*Harrington v. State*, 2001, p. 12) as “the study that we did initially on the students.” Contrary to Rosenfeld’s (2005) statements, the information was not “recently acquired” nor were the subjects “well practiced.” Farwell described the study as follows in his testimony in the *Harrington v. State* (pp. 7 - 8).

A Yes. The first study that I did, which actually later became a part of that Farwell and Donchin 1991 paper, was a study of detecting information about minor crimes or socially undesirable acts in the lives of college students. Basically, what we did is we got four college students, we went with their permission, to their roommates, and asked them about some situation that they had done that was either a crime or some socially undesirable act. We didn't tell the person we were testing what that situation was that we were looking for. And we developed a set of words or phrases, some of which were relevant to that particular event, and others weren't. I can describe in more detail, but in any case, some of these phrases or words were relevant to that, and others weren't. We presented those on a computer screen mixed in with other irrelevant items, and we could tell by the brain response by this P300 which ones the subjects recognized.

Contrary to Rosenfeld's (2005) false statement, both Experiment 2 of Farwell and Donchin (1991) and the Farwell and Smith (2001) study contain support for exactly the kind of real-life (or as Rosenfeld called it "retrospective") testing applied in the Harrington case. In neither case was the information "recently learned." In neither case were the subjects "well practiced."

These same facts make it clear that second sentence quoted above is false: "There is, in fact, no published, peer reviewed, scientific evidence whatsoever supporting this retrospective testing as was done in the Harrington case" (Rosenfeld, 2005, p. 31). Contrary to Rosenfeld's false statement, both Farwell and Smith (2001) and Farwell and Donchin (1991) provide "published, peer reviewed, scientific evidence" supporting the kind of testing conducted in the Harrington case.

These same facts demonstrate that another similar statement Rosenfeld (2005) made is false as well: "[A] criminal suspect in the field would hardly have had the kind of rehearsal opportunities present in both experiments of Farwell and Donchin (1991)" (p. 24). There were no "rehearsal opportunities" in Experiment 2, the real-life experiment. Rosenfeld stated, without evidence, that the subjects in Experiment 2 "*no doubt had had much review of their crimes at the hands of campus investigators, teachers, parents, etc.* [*italics in original*]" (p. 24). Rosenfeld's speculation is without foundation or evidence, and is in fact false. No such review was mentioned in Farwell and Donchin, and no such review took place. (The present author knows this because he interviewed all of the subjects and informants.)

All three expert witnesses, including the expert witness on the opposing side, testified that Farwell and Donchin's (1991) use of the P300, explicitly including both Experiment 1 and the real-life Experiment 2, was well accepted in the scientific community (*Harrington v. State*, 2001). As described in detail above, the expert witnesses provided sufficient information regarding the validity of brain fingerprinting science and its acceptance in the scientific community that the court ruled the brain fingerprinting evidence and Farwell's testimony on it admissible (*Harrington v. State*, 2001).

Rosenfeld falsely alleged that the Brain Fingerprinting Laboratories website misrepresented the role of brain fingerprinting in the Harrington case.

Rosenfeld (2005) stated: "The BF Web site clearly suggests that the BF evidence was of major importance in that Supreme Court decision. (Recall also the 'get-out- of-jail card,' noted above and in Figure 4.)" (p. 30).

In the context of his false statements regarding the "get-out-of-jail card," Rosenfeld (2005) reproduced the heading of a page about the Supreme Court decision from the Brain Fingerprinting Laboratories website, as follows:

> Iowa Supreme Court overturns the 24 year old conviction of Terry Harrington,
>
> Brain Fingerprinting Test aids in the appeals;
>
> Iowa Supreme Court Reverses Harrington Murder Conviction after 24Years
>
> Brain Fingerprinting Test Supports Innocence (p. 31).

On the same web page referred to by Rosenfeld (2005; http://www.brainwavescience.com/IowaSupCourtPR.php), the Brain Fingerprinting Laboratories, Inc. website clearly and accurately stated the role of the brain fingerprinting evidence in the Iowa District Court and the Iowa Supreme Court, as follows:

> Following a hearing on post-conviction relief on November 14, 2000, an *Iowa District Court* [*italics added*] held that Dr. Farwell's Brain Fingerprinting P-300 test results were admissible as scientific evidence….
>
> Today, the *Iowa Supreme Court* [*italics added*] reversed the District Court's decision *on constitutional grounds* [*italics added*] and left undisturbed the law of the case establishing the admissibility of the Brain Fingerprinting evidence….
>
> The *Iowa Supreme Court* [*italics added*] determined that its constitutional finding *made it unnecessary to examine the newly discovered [brain fingerprinting] evidence*…. [*italics added*].

The same Brain Fingerprinting Laboratories, Inc. web page quoted in its entirety the supreme court's discussion of the brain fingerprinting evidence. It also provided a link to the full text of the Iowa Supreme Court decision.

The referenced web page not only did not "clearly imply," as Rosenfeld (2005) falsely stated, "that the BF evidence was of major importance in that Supreme Court decision" (p. 30). The Brain Fingerprinting Laboratories, website explicitly and accurately stated that the supreme court did not reach a consideration of the brain fingerprinting evidence. It stated accurately that the brain fingerprinting evidence was ruled admissible in the district court, and that the supreme court left undisturbed the law of the case, including the district court's admitting the brain fingerprinting evidence. (Note that "the supreme court left undisturbed the law of the case" is a legal term of art signifying that in their review of the case, the supreme court could have reversed the district court's decision to admit the brain fingerprinting evidence, but elected to let it stand.)

In short, once again Rosenfeld's (2005) allegation is false, particularly in light of the fact that it was presented in the context of Rosenfeld's false attribution to Farwell of a statement that Farwell did not make.

The scientific and legal role of brain fingerprinting in the Harrington case is described in the section entitled "The Harrington Case," and in more detail in writings by Farwell and his attorney Tom Makeig (Farwell & Makeig, 2005) and others (Erickson, 2007; Moenssens, 2002; Roberts, 2007).

Rosenfeld misrepresented the fundamental procedures of brain fingerprinting testing and falsely accused Farwell of not correctly representing them.

Rosenfeld misrepresented the fundamental procedures of brain fingerprinting testing. Although such a false description of the fundamental science involved is not defamatory, it is extremely important in the context of a purportedly scientific critique of Farwell's scientific methods. One of the most important fundamental distinctions that Farwell has made both in his peer-reviewed scientific writings and in his courtroom testimony is the distinction between detecting lies and detecting information. These are fundamentally different processes, scientifically and legally. Clearly understanding that brain fingerprinting detects information and not lies, and acting accordingly, is one of the fundamental brain fingerprinting scientific standards (see Farwell, 2012).

Rosenfeld (2005) quoted Farwell in Farwell and Smith (2001) and other sources as stating that brain fingerprinting is distinct from lie detection, since it detects information, not lies. He then went on to falsely state that Farwell's statements to this effect are "misleading" (p. 22). In support of his false contention, Rosenfeld entirely misrepresented the scientific procedures of brain fingerprinting, as follows.

In brain fingerprinting and several other techniques, subjects press one button in response to target stimuli (information known to the subject) and a different button for both irrelevant stimuli and probes (the latter are the crime-relevant information being tested). The subject instructions are vital for determining what mental task the subject is actually performing while his brainwaves are being measured, and consequently what the science is in fact measuring.

Regarding brain fingerprinting methods, Rosenfeld (2005) falsely stated: "One button means 'No, I don't recognize this stimulus.' If the guilty subject presses this no button to a guilty knowledge [probe] item, he is lying with his button press, if not his voice" (p. 22).

This may be the case in Rosenfeld's methods (e.g., Rosenfeld et al., 2004), which have fundamentally different subject instructions that may in fact tell the subject that pressing the button as instructed constitutes a "lie." Rosenfeld's description of the experimental protocol is not true of brain fingerprinting, however. In brain fingerprinting, the subject is given a list of the target stimuli and instructed to press one button in response to targets, and another to all other stimuli (Farwell & Donchin, 1991; Farwell & Smith, 2001; *Harrington v. State*, 2001). The latter include irrelevant stimuli and crime-relevant probe stimuli. The subject is not instructed to lie, or given any opportunity to lie during the test. Nor is he told that his button-press responses constitute "lies." Whether he has something to hide or not, the subject neither tells the truth nor lies by his button presses during the test. He simply presses buttons as instructed.

Brain fingerprinting, like all other forensic sciences, can of course be used to catch a subject in a lie that takes place outside of the scientific procedure. Any forensic evidence – including DNA and fingerprints as well as brain fingerprinting results – can indirectly be used to catch a subject in lie if that lie is a false denial of participation in a crime. This use outside of the scientific procedure itself, however, does not somehow transform these scientific procedures into lie-detection techniques.

In Rosenfeld's studies (e.g., Rosenfeld et al., 2004) and some other laboratory experiments that are in some ways similar to brain fingerprinting – and in other ways fundamentally different – subjects are told that following the instruction to press a specific button in response to probes constitutes a "lie." In such a situation, however, this would not be a lie by any reasonable definition. There is no intent to deceive. There is no attempt to actually deceive the experimenter by pressing the button exactly as the same experimenter has instructed the subject to do. The cooperative laboratory subject presses the button he is instructed to press. This action involves simply obeying subject instructions to do something the experimenter knows the subject will do. This button press does not somehow become a lie by the experimenter naming it a lie.

In any case, the brain fingerprinting scientific protocols simply instruct the subject to press one button in response to targets and another button in response to all other stimuli. There is no pretense that this constitutes a lie. Lying or any pretense of lying is entirely absent from brain fingerprinting scientific protocols. Whether the subject lies about his participation in the crime before or after the test is an entirely independent question, and has no effect on the brain fingerprinting test.

In their seminal publication on the subject, Farwell and Donchin (1991) used the term "interrogative polygraphy" as an umbrella concept including both detection of deception and detection of information, through both central-nervous-system and peripheral measures. They made it clear in the publication that the methods reported therein are for the detection of information, not lies. The title of the article is "The truth will out: Interrogative polygraphy ('lie detection') with event-related potentials." The term "lie detection" was enclosed in quotation marks to emphasize that it is not meant literally, as anyone who reads the article or even the abstract will clearly recognize. Farwell and Donchin state explicitly stated that the term "lie detection" is "inaccurate and misleading" (p. 531).

Despite Farwell and Donchin's (1991) explicit statements to the contrary, Rosenfeld (2005) falsely took their inclusion of the words "lie detection" in the article as evidence that brain fingerprinting is "lie detection," and that brain fingerprinting actually attempts to detect lies.

In short, Rosenfeld (2005) falsely described the fundamentals of brain fingerprinting testing, falsely described the relevant scientific procedures, and falsely accused Farwell of not being truthful about the procedures when Farwell described them accurately. Rosenfeld falsely characterized brain fingerprinting as lie detection, and falsely stated that Farwell's statements distinguishing brain fingerprinting from lie detection are "misleading." To support his position, Rosenfeld misrepresented and incorrectly described the well-documented brain fingerprinting experimental protocol.

Rosenfeld falsely attributed to Farwell obviously illogical "implications" that Farwell never stated or implied.

Rosenfeld falsely attributed to Farwell a number of obviously illogical "implications" that neither Farwell nor any other competent brain fingerprinting scientist ever stated or implied. Rosenfeld (2005) falsely stated that Farwell and Smith's (2001) statements regarding the applicability of brain fingerprinting in detecting crime-relevant information stored in the brain contain a "critical implication" that "The brain is constantly storing undistorted, detailed representation of experience that the BF [brain fingerprinting] method can extract from the brain just as easily as real fingerprints can be lifted from murder weapons" (p. 24).

Neither Farwell nor any other scientist has ever stated or implied such an "implication."

These facts are indisputable: 1) the brain is intimately involved in the commission of every crime; 2) the brain constantly stores a record of our experiences of all kinds. It goes without saying that this is not a perfect record. Neither Farwell nor anyone else one thinks or says otherwise.

Obviously, it is not necessary for the representation of experience stored in the brain to be "undistorted, detailed" for the information stored in the brain to be useful in criminal investigations. Eyewitness testimony depends entirely on memory, and is routinely used in investigations and universally admitted in court. This does not mean that the courts are foolish enough to believe the above "implication." The courts' universal admittance of witness testimony means two things: 1) the courts recognize that the brain stores information with sufficient accuracy for remembered information to be useful in court proceedings; and 2) judges, juries, and everyone else with common sense are aware of the fact that memory is imperfect, and they routinely take this into account in their deliberations.

The same considerations that apply to the information stored in the brain that is reported in eyewitness testimony also apply to the information stored in the brain that is detected by brain fingerprinting. In both cases, judges and juries are capable of weighing and evaluating the probative value of information stored in a subject's brain while taking into account common sense and the well known fact that memory is not "undistorted, detailed." Farwell has discussed the limitations of human memory and their implications for interpretation of brain fingerprinting results extensively elsewhere (Harrington v. State, 2001 and the reports presented as evidence therein). This is also discussed in the next section below.

The above facts make it clear that Farwell's statements regarding brain fingerprinting and memory are fundamentally different from the notions that Rosenfeld (2005) attributes to him – notions that are clearly illogical on their face and that grossly misrepresent Farwell's well documented position.

Brain fingerprinting, witness testimony, and the limitations of human memory.

Human memory is not perfect. It is affected by myriad factors, including mental and physical illness, trauma, injury, drugs, aging, passage of time, and many other well known factors.

The limitations on human memory already figure prominently in all judicial proceedings that include testimony by witnesses or suspects, whether they involve brain fingerprinting evidence or not. A witness, even if he is truthful, does not testify to the absolute truth. He testifies only to the contents of his memory. This is the case with expert witnesses as well as with eyewitnesses.

To perform their evaluation of witness testimony adequately, judges and juries must already be aware of the well established limitations on human memory and use their common sense to take them into account. Judges and juries must apply these exact same considerations and common sense when weighing brain fingerprinting evidence.

The argument that brain fingerprinting evidence should not be admitted or considered due to the limitations of human memory is without merit in any forum that admits witness testimony of any kind. Witness testimony constitutes a subjective report of the contents of memory. Brain fingerprinting constitutes objective, scientific evidence of the contents of memory. In any forum where subjective reports of the contents of memory are considered, objective evidence of the contents of human memory warrant at least the same treatment. For brain fingerprinting, witness testimony, and also for confessions, the well-known limitations of human memory go to the weight of the evidence, not to admissibility or applicability.

When the brain fingerprinting determination is "information present," the limitations of human memory play a minor role. Despite these limitations, in such a case brain fingerprinting has shown that the suspect knows details about a crime, details that he has previously claimed not to know and has no reasonable explanation for knowing other than having participated in the crime.

With brain fingerprinting science, as with all science, the judge and jury must interpret negative findings reasonably and with caution. (The brain fingerprinting scientist does not interpret the results; he simply reports the determination of "information present" or "information absent" with respect to the specific information contained in the probes provided by the criminal investigator, along with the statistical confidence for the determination.) When the brain fingerprinting determination is "information absent," then the judge and jury must use common sense and take into account the limitations on human memory in the same way as they do when weighing witness testimony.

Conducting a brain fingerprinting test on the alibi as well as the crime can help to minimize the possibility that the subject's lack of knowledge of the crime was due to a catastrophic memory failure. (Note, however, that an "information present" determination with respect to the alibi does not prove that the alibi is true, only that the subject's memory of the alibi is intact.)

The effect of the imperfections of human memory and perception on brain fingerprinting evidence is identical to the effect of these factors on the testimony of a witness.

The evidence provided by a brain fingerprinting test is limited to a specific determination as to whether certain information is stored in the subject's brain or not. (See discussion of brain fingerprinting scientific standards in Farwell, 2012.) The brain fingerprinting determination is "information present" or "information absent" with respect to the specific probe stimuli provided by the criminal investigators, which in the criminal investigators' judgment are salient features of the crime.

Neither brain fingerprinting science nor any other science tells us directly what took place at the crime scene, or whether a particular individual is guilty of a particular crime. Like DNA, fingerprints, and every other forensic science, brain fingerprinting science does not provide a determination of "guilty" or "innocent," or a determination that this suspect did or did not do specific actions. The value of brain fingerprinting science is that it can provide evidence that the triers of fact can productively use in their decisions regarding what took place and who was involved. Brain fingerprinting science does not determine what the facts are, other than the one fact of presence or absence of specific information stored in a specific brain. This is the only fact about the crime or the suspect that the brain fingerprinting scientist addresses in his expert testimony.

The role of brain fingerprinting science in judicial proceedings is to provide evidence that the judge and jury can utilize in reaching their verdict. This evidence must be considered along with all other available evidence. Like other evidence and witness testimony, it must be considered in light of the known limitations on human memory.

For a forensic scientist, the import of all discussions about human memory is simply the following: Draw scientific conclusions only regarding what the subject knows at the time of the brain fingerprinting test. This is one of the fundamental brain fingerprinting scientific standards (see Farwell, 2012).

For the judge or jury, memory considerations can be summarized as follows. The contents of human memory are revealed subjectively (and not always truthfully) by witness testimony, and objectively by brain fingerprinting. In weighing the evidence and extrapolating from facts regarding the contents of human memory to facts regarding crimes or guilt, use common sense and take into account the well known limitations of human memory.

Farwell has made it extremely clear in scientific writings, public statements, and expert witness testimony that brain fingerprinting detects information stored in the brain, not guilt or innocence, or participation in any act. Farwell has never espoused Rosenfeld's (2005) absurd "implication" that because scientific data on the information stored in the brain can be useful in judicial proceedings, "The brain is constantly storing undistorted, detailed representation of experience" (p. 24).

Farwell has consistently recognized and stated that the determination of who did what, of guilt or innocence, is a legal determination to be made by a judge and jury, not a scientific determination to be made by a scientist or computer. In the entire 242-page transcript containing Farwell's expert testimony in the Harrington case (*Harrington v. State*, 2001) there is not a single statement by Farwell regarding Harrington's innocence or guilt of the crime, or regarding what Harrington did or did not do. Farwell sticks to what the science proved: that Harrington did not know certain specific details about the crime when tested with brain fingerprinting. It is up to the judge and jury to weigh this evidence along with all of the other evidence in reaching their determinations regarding guilt or innocence.

The above facts make it clear that Farwell's statements regarding brain fingerprinting and memory are fundamentally different from the obviously illogical notions that Rosenfeld (2005) attributes to him. Farwell has never stated or implied anything remotely resembling the "implication" that Rosenfeld attributed to him and other brain fingerprinting experts.

In short, with respect to human memory, Rosenfeld falsely attributes to Farwell an "implication" that Farwell did not state or imply, that directly contradicts what Farwell has consistently said and written, and that is so absurd that no one would believe it or take it seriously.

Rosenfeld falsely stated that brain fingerprinting is susceptible to countermeasures, when his research showed only that his alternative techniques are susceptible to countermeasures.

Rosenfeld (2005) falsely stated that brain fingerprinting has been shown to be susceptible to countermeasures. He cited as evidence a paper that he published in 2004 (Rosenfeld et al., 2004). Rosenfeld et al. report several different experiments and several different data-analysis and statistical methods. In every case, they used fundamentally different subject instructions, statistics, data acquisition procedures, and methods (or lack of methods) for establishing ground truth than those of brain fingerprinting. As noted above, their methods failed to meet 15 of the 20 brain fingerprinting scientific standards.

Rosenfeld's false statement that his research shows that brain fingerprinting is susceptible to countermeasures is one of the false statements that were previously published by other unsuspecting publishers and then corrected after they checked the facts, as described above.

Unlike Rosenfeld's various techniques described herein, brain fingerprinting has proven to be highly resistant to countermeasures. Farwell (2008) tested countermeasures in a series of brain fingerprinting tests on actual crimes. In order to produce life-changing effects regardless of judicial outcomes, Farwell and colleagues have offered perpetrators of actual crimes a $100,000 cash reward for beating the brain fingerprinting test. The subjects were trained in Rosenfeld's et al.'s (2004) countermeasure described above. No one has succeeded in beating the test. Brain fingerprinting accurately detected the crime-relevant knowledge in all such subjects, with no false positives, no false negatives, and no indeterminates.

As a result of the fundamental differences between Rosenfeld's methods and those of brain fingerprinting, Rosenfeld et al. (2004) did not achieve the consistently extremely high accuracy rates achieved by brain fingerprinting. For some of Rosenfeld's methods, accuracy was as low as 54%, no better than chance. All but one of their methods are very different from brain fingerprinting. Even their method that they correctly characterize as most similar to brain fingerprinting lacks some of the most essential features of brain fingerprinting subject instructions and tasks, statistics, data acquisition methods, and methods for establishing ground truth. Their methods that they tested generally were found to be susceptible to countermeasures.

In their only method that was even somewhat similar to brain fingerprinting, however, they report that countermeasures had no effect at all. Rosenfeld et al. (2004) showed that *their* alternative, non-brain fingerprinting methods were susceptible to countermeasures, but the only results that might be construed to apply to brain fingerprinting showed no effect of countermeasures. (Countermeasures would have been unnecessary, however, since the accuracy of their specific method was only 54% even without countermeasures.)

The countermeasure taught in Rosenfeld et al. (2004) was to perform covert actions such as wiggling the toe in response to each irrelevant stimulus. This was predicted to increase the P300 amplitude to irrelevants, thus lessening the difference between probe and irrelevant brainwave responses.

The same subjects had slower reaction times to the stimuli when they were not practicing this countermeasure. Reaction times, however, are easily manipulated and therefore not suitable for detection in real-life situations with real consequences.

Rosenfeld and colleagues conducted other studies that showed that his non-brain fingerprinting methods were susceptible to countermeasures. One study (Rosenfeld et al., 2008) failed to meet 13 of the 20 brain fingerprinting scientific standards (see Farwell, 2012). Accuracy was 92% without countermeasures and 83% when subjects practiced Rosenfeld et al.'s (2004) countermeasure described above. Another study (Meixner et al., 2009) failed to meet the same standards and resulted in 36% accuracy (lower than chance) with countermeasures.

As discussed above, these and other recent studies using Rosenfeld's complex trial protocol also suffered from a fatal procedural error that made Rosenfeld's method unusable in the field.

Rosenfeld and colleagues' detection rates in laboratory experiments with this technique for subjects who were practicing countermeasures have ranged from 36% (Meixner et al., 2009) to 100% (Meixner & Rosenfeld, in press) and averaged approximately 71%. The inescapable conclusion is that Rosenfeld's technique, and not brain fingerprinting, is susceptible to countermeasures. As described above, it is also fatally flawed and consequently unusable in the field.

Moreover, Rosenfeld's "complex trial protocol" has produced 0% accuracy in real-world situations with motivated subjects, because all subjects have figured out how to beat the test without even being taught countermeasures (Farwell et al., 2013).

Another non-brain fingerprinting study, Mertens and Allen 2008 (2008), found similar countermeasures to be effective against their procedure. As discussed above, their procedure failed to meet the brain fingerprinting scientific standards, resulting not only in susceptibility to countermeasures but also in very low accuracy even without countermeasures.

Other countermeasure experiments (Sasaki, Hira, & Matsuda, 2002) found a simple mental-task distraction countermeasure to be ineffective.

In short, Rosenfeld falsely stated that published results show that brain fingerprinting is susceptible to countermeasures, whereas actual published research points to the opposite conclusion. Rosenfeld's research has shown only that his methods, and not brain fingerprinting, are susceptible to countermeasures. Farwell's research on real-life crimes has shown that brain fingerprinting is not susceptible to Rosenfeld's countermeasures.

Rosenfeld falsely attributed to Farwell statements made by others, and on that basis falsely criticized Farwell for allegedly exaggerating the accuracy of brain fingerprinting.

Rosenfeld (2005) falsely contended that Farwell has made inflated claims regarding the accuracy of brain fingerprinting. Rosenfeld stated:

"Another of Farwell's Web sites implies that the technique has perfect accuracy by using the phrase '100% accurate' as the subheading of large sections of text (e.g., http://www.brainwavescience.com/Chemistry.php)." (p. 21).

The text in question was not a statement by Farwell or a quotation attributed to Farwell. It appeared only within an article published in *Chemistry and Industry* in March 2004 (Murphy, 2004) that was reproduced in its entirety on the Brain Fingerprinting Laboratories website (see http://www.brainwavescience.com/Chemistry.php). Moreover, the text below the subheading (written by Murphy, not Farwell) clearly and correctly states that the term 100% was applied to results actually obtained in specific studies and applications, not to a general characterization of the technology by Farwell or anyone else.

With respect to accuracy, in Farwell's public and private statements, including the ones cited by Rosenfeld (2005), Farwell has consistently stuck to the established facts. Legitimate commentators who have extensively reviewed the relevant literature and other sources have recognized this.

For example, Moenssens (2002) stated:

> Despite his acknowledgment of these and other astounding results, Dr. Farwell claims neither a 100 percent accuracy rate nor a zero percent error rate. Such a claim, he states, is scientifically indefensible.[53] Instead, he asserts that his analytical techniques, using statistical methods accepted in the relevant scientific community, produce high statistical confidence levels for each determination. [54] (p. 900).

In support of this conclusion, Moenssens (2002) cited scientific and other publications, Farwell's expert witness testimony in court, Farwell's scientific reports that were admitted as evidence in court, and Farwell's public statements.

Erickson (2007), after extensively reviewing these and similar sources, reached a similar conclusion: "…existing studies support Farwell's assertions regarding the accuracy of Farwell's design and methodology"(p. 16).

In his scientific publications, expert testimony, court documents, scientific reports, and public statements, Farwell has correctly stated the actual accuracy rates achieved in his various studies. He has used the term "100%" only as a statement of specific, actual past results achieved, never as a prediction of future results or a general characterization of the technology. Everyone knows, and Farwell has stated countless times, that there is no such thing as a "100% accurate" in any science – there is always a margin for error, a margin of uncertainty. It is, however, correct to use the number 100% (and incorrect to use any other figure) when reporting on *specific past results* wherein the accuracy was in fact 100%. A technology can, and brain fingerprinting does, have a *record* of 100% accuracy *in past research and applications*. Correctly stating this established fact about the past – which the brain fingerprinting web site does – is not the same thing as predicting a 100% accuracy rate in the future – which the web site has never done and Farwell has never done.

In over 100 interviews in the national and international press, Farwell has never once predicted a specific accuracy rate for future uses of brain fingerprinting. Even when pressed, he has refused even to predict that brain fingerprinting will achieve the specific numerical accuracy (100%) in future real-life cases that it has in past real-life cases (*Harrington v. State*, 2001; Moenssens, 2002; Roberts, 2007).

For example, Farwell addresses this question of "100% accuracy" directly in the *Supplement to Forensic Science Report: Brain Fingerprinting Test on Terry Harrington*. Farwell prepared this report for the Harrington case. It was admitted as evidence in the Harrington trial (*Harrington v. State*, 2001).

> QUESTION: If 100% of the determinations made were correct, does this mean that brain fingerprinting is "100% accurate," that it will always solve every crime and can never make a mistake?
>
> DR. FARWELL: In science, nothing is absolutely 100%. There is always a level of uncertainty. Fortunately, when we encounter a situation where no definite determination can be made with a high statistical confidence, then the system produces an "indeterminate" result. This is done mathematically. This avoids making an error when there is insufficient data, and also avoids the scientifically untenable position of claiming that the system is perfect and could never fail to give us a definite and accurate solution to any crime. Like any scientific evidence, the information provided by brain fingerprinting is not be taken as an absolute. It must be evaluated and weighed along with all of the other available evidence.

Farwell has stuck to the truth, publicly and privately, regarding the accuracy and applicability of brain fingerprinting. Rosenfeld's (2005) false statements about Farwell in this regard are particularly noteworthy in light of the fact that Rosenfeld himself has made unsupported claims and demonstrably false claims for specific accuracy figures in future uses of his alternative technique, as well as unsupported claims regarding its suitability for field use, as described above (Hansen, 2009). Rosenfeld claimed that his techniques could accurately detect terrorists, despite the fact that Rosenfeld has not achieved accurate detection even in the laboratory, nor have his methods been tested in anything remotely resembling a real-life criminal or terrorism investigation. Moreover, as discussed above, his method suffers from two fatal flaws that make it unusable in a field environment.

Rosenfeld's Other Misleading Statements, Unsupported Subjective Opinions, and Other Irrelevant and Insubstantial Information Included in his Article

Rosenfeld's doubts about the value of brain fingerprinting for government agencies are unsupported by relevant, current evidence.

Rosenfeld (2005) stated, "There is considerable doubt, however, about [brain fingerprinting] fulfilling urgent needs by U.S. government agencies" (p. 34.) "It is documented that, in fact, U.S. government agencies most concerned with detecting deception do not envision use of BF" (p. 20.)

He cited as evidence for his contention a 2001 report entitled "Federal Agency Views on the Potential Application of 'Brain Fingerprinting'" issued by the US General Accounting Office (GAO) (General Accounting Office, 2001). The report was essentially a sampling of opinions of individuals associated with detection of deception in the federal government prior to 9-11. (It was completed before 9-11-2001 and issued shortly thereafter.) It reported that most such individuals interviewed did not see the need for brain fingerprinting in their pre-9-11 operations nearly a decade ago. The report stated:

> 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. (p. 2)

The report noted, however, that the only two US government scientists interviewed who had conducted research on brain fingerprinting both were convinced that it would be useful in FBI investigations.

The report did not include an account of the scientific research on brain fingerprinting or its successful use in court. The report did not discuss the value of brain fingerprinting for other applications other than general screening, for which it does not apply, as discussed above. The GAO did not evaluate or opine on the effectiveness, accuracy, or validity of brain fingerprinting. The report stated:

> …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. (p. 4).

The report concluded that a number of federal officials did not see an immediate application for brain fingerprinting in their general screening operations before 9-11. The report constituted a reasonably accurate opinion poll of federal employees associated with detection of deception a nearly a decade ago. This is not relevant to the validity, value, accuracy, or current applicability of brain fingerprinting.

An analysis of the current inner workings of US intelligence, national security, law enforcement, military, and special operations agencies, and those of other countries, is beyond the scope of this article. Suffice it to say: that was then, this is now.

Senator Charles Grassley, who commissioned the original GAO report, has asked the GAO (now renamed Government Accountability Office) to develop a new report addressing the post-911 situation. He asked the GAO to discuss the applications of brain fingerprinting in criminal investigations and counterterrorism in the post-9-11 world. He also asked the GAO to include the views of experts well versed in brain fingerprinting and MERMER technology, and to include the brain fingerprinting research at the FBI, CIA, and US Navy.

Rosenfeld (2005) is entitled to doubt that brain fingerprinting currently fulfills an urgent need for governments and law enforcement agencies, but a nine-year-old, pre-9-11 report soon to be supplanted by a more current assessment is insufficient evidence to be convincing that his doubt is well founded in current reality.

Rosenfeld offered his subjective opinions regarding the waveform plots in the Harrington case; subjective opinions are irrelevant to the brain fingerprinting scientific determination.

Rosenfeld (2005) spent considerable verbiage discussing his subjective opinions of the plots of Harrington's brainwave responses and other waveforms. He is entitled to his opinions, but this is not how brainwave responses are analyzed in brain fingerprinting. In brain fingerprinting, determinations are computed using a mathematical algorithm, not arrived at by subjective assessment based on looking at the waveform plots.

In two of his studies, Rosenfeld and colleagues computed no statistics on individual subjects (Rosenfeld et al., 1987, 1988), but rather made determinations based on his own subjective judgment from looking at plots of the waveforms. His procedure fails to meet the relevant brain fingerprinting scientific standards regarding objective metrics for determinations (see Farwell, 2012) as well as about a dozen other brain fingerprinting standards. He is entitled to report his own results in terms of his subjective impressions of waveforms, but his opinions do not affect the scientific, mathematical procedures used to make the determination in the Harrington case.

Rosenfeld (2005) commented extensively on his subjective opinions regarding the size and shape of the various waveforms reproduced on the Brain Fingerprinting Laboratories website and elsewhere. He noted correctly that it appears that the P300-MERMER appears to be maximal at the parietal area, although it can also be observed at the frontal area. Rosenfeld stated incorrectly that Farwell and Smith (2001) and Farwell's patent (Farwell, 1994) characterize the late negative peak (LNP) of the MERMER as largest in the frontal area. (This is apparently simply an unintentional and harmless error by Rosenfeld, and not a deliberate misrepresentation.) Farwell stated, in these references and elsewhere, that the late negative peak (LNP) of the p300- MERMER is *maximal* in the parietal area and also *prominent* in the frontal area.

> [T]he raw voltage potentials (compared to a pre-stimulus baseline) of both the earlier positive aspect [P300] and the late negative aspect [LNP] of a MERMER elicited by a probe or target stimulus are widespread. The former is generally largest at the parietal area, followed by the central and frontal areas in that order. The latter is generally slightly larger at the parietal area than at the frontal area. (Farwell, 1994, col. 10).

Granted, the terminology can be confusing. The Brain Fingerprinting Laboratories webmaster, too, made an error, which has been corrected. The website inadvertently used an outdated version of a pre-publication draft of a paper that contained a typo, substituting the word "maximal" for "prominent." This typographical error has been corrected. (See http://www.brainwavescience.com/FBIStudy.php.)

Rosenfeld (2005) made various speculations about the characteristics of the P300-MERMER, and asked a number of questions about its characteristics. The scientific way to answer such questions is by conducting scientific research, as Farwell and others have done and will undoubtedly continue to do as more and more knowledge comes to light about this relatively newly discovered phenomenon.

Rosenfeld expressed his opinions on optimal digital filters but did not conduct relevant research.

Rosenfeld (2005) discussed Farwell et al.'s (1993) published research on optimal digital filters. Farwell et al. pioneered the use of optimal digital filters in event-related brain potential research. These filters are optimal in the strict mathematical sense. They provide very precisely specifiable performance characteristics. Farwell et al. conducted research showing that optimal digital filters have advantages over other previously used, less sophisticated filters for long-latency event-related brain potential research. Many laboratories now use these optimal digital filters.

Farwell et al. (1993) conducted their research on real EEG data. Rosenfeld (2005) suggested, but did not conduct, research using artificial data. He expressed his various opinions regarding the type of research to conduct and the type of filters to use. He reprinted his email exchanges with others on this subject. Rosenfeld is of course entitled to his opinions, but science only advances when people not only express opinions but also test them with scientific research. Farwell et al. have conducted such research on digital filters. Rosenfeld has not.

Rosenfeld discussed the relative merits of optimal digital filters as compared to simpler, moving-average filters that are not optimal (in the precise, mathematical sense of the term). Optimal digital filters are used in brain fingerprinting and, since their introduction in the analysis of ERPs by Farwell and colleagues in their seminal publication (Farwell et al., 1993), are also used by many other event-related brain potential researchers.

The ostensible relevance of this to the present discussion is Rosenfeld's (2005) contention that the superiority of optimal digital filters is insufficient to explain the markedly higher accuracy of brain fingerprinting methodology when compared to the alternative methods practiced by Rosenfeld (e.g., Rosenfeld et al., 2004, 2008) and other alternative methods practiced by others. This is a moot point, because all of the researchers who have achieved much lower accuracy rates than those achieved by Farwell and colleagues with brain fingerprinting have not only used different filters. Rosenfeld and others who obtained low accuracy rates have also applied methods that differ substantially from those of brain fingerprinting with respect to other major factors. In particular, the researchers who have achieved accuracy rates as low as chance, including Rosenfeld et al. (2004, 2007) and Miyake et al. (1993), have used markedly different methods than those of Farwell's brain fingerprinting. Many of these differences are described in detail in the above mentioned section.

Rosenfeld included his personal email exchanges, speculation on what others might think or say, etc., and did not include extensive relevant material.

Rosenfeld (2005) spent considerable verbiage touting his own research, discussing news reports (and falsely attributing statements of reporters to Farwell), reproducing his own email correspondence, discussing his subjective opinions about the graphics and wording on the brain fingerprinting web site and various other subjects. He speculated about what Farwell might say about various subjects. Rosenfeld did not, however, include some of the most significant and relevant information a reader would require to make an informed decision regarding brain fingerprinting. Rosenfeld did not include the vast majority of the relevant material discussed in this paper in all of the sections prior to the section in which we correct Rosenfeld's (2005) misstatements.

For example, Rosenfeld (2005) failed to describe the process through which brain fingerprinting was ruled admissible in court, the standards for admissibility, or how and why the court ruled that brain fingerprinting meets these standards. This is described above in the discussion of the Harrington case (*Harrington v. State*, 2001).

Rosenfeld (2005) did not describe how Farwell's brain fingerprinting science and technology, unlike Rosenfeld's methods (e.g., Rosenfeld et al., 2004) which he touted in the article, have been successfully used in real-life applications including criminal cases in the field. For example, Farwell's brain fingerprinting was instrumental in bringing serial killer J. B. Grinder to justice, as described above.

Rosenfeld (2005) did mention that *Time* magazine selected Farwell to the Time 100: The Next Wave, the innovators who may be "the Einsteins or Picassos of the 21st Century," but only to criticize *Time*'s selection as indicating that they "uncritically accepted" Farwell's discoveries and inventions. Time did their own research on Farwell and his scientific discoveries and inventions, and Farwell did not know he was being considered for the honor until after *Time* had made their decision.

Summary of Rosenfeld's (2005) *SRMHP* Article

The Rosenfeld (2005) article in *SRMHP* contains numerous demonstrably false statements and extensive misinformation, which in the interest of limiting the length of our article we have corrected only in part above. It contains Rosenfeld's unsupported and incorrect speculation about experiences in the lives of Farwell's subjects, and Rosenfeld's baseless and incorrect scientific conclusions about Farwell's research based on thereon. It contains irrelevant information, such as Rosenfeld's touting his own non-brain fingerprinting research. It contains inappropriate information, such as Rosenfeld's personal emails, his unsupported subjective opinions, and his speculations as to what Farwell might say (but did not say) on various subjects. If all of these were removed, the article would contain virtually nothing of substance.

Rosenfeld used the *SRMHP* article (Rosenfeld, 2005) and the false statements he made therein to provide purported support for his subsequent false statements about brain fingerprinting and also his subsequent false claims regarding his own technique (Hansen, 2009; Rosenfeld et al., 2008).

Summary and Conclusion: Brain Fingerprinting

Brain fingerprinting is a scientific technique to detect concealed information stored in the brain by measuring brainwave responses non-invasively. An EEG event-related potential brain response known as a P300-MERMER is elicited by stimuli that are significant in the present context. Brain fingerprinting detects a P300-MERMER response to words or pictures relevant to a crime or terrorist act, terrorist training, bomb-making knowledge, inside knowledge of a terrorist cell or intelligence agency, etc.

Brain fingerprinting detects information stored in the brain by measuring cognitive information processing. Brain fingerprinting is not lie detection. It does not detect lies, stress, or emotion.

The brain fingerprinting system computes a determination of "information present" (the subject knows the crime-relevant information) or "information absent" (he does not know it) and a statistical confidence for the individual determination. Laboratory and field tests at the FBI, CIA, US Navy and elsewhere have resulted in no false positives and no false negatives; 100% of determinations made by brain fingerprinting have been correct. Overall, including studies that measure only the P300 and studies that measure the full P300-MERMER, 3% of results have been "indeterminate." Since the inclusion of the full P300-MERMER in the computations, there have been no false positives, no false negatives, and no indeterminates: 100% of tests have produced correct determinations.

Farwell has successfully applied brain fingerprinting in criminal cases, including helping to bring serial killer J. B. Grinder to justice. Brain fingerprinting and Farwell's expert testimony on it have been ruled admissible in trial court.

Effective application of brain fingerprinting in the laboratory and the field requires an understanding of the relevant scientific principles and the proper role of brain fingerprinting in forensic science and judicial proceedings. Maintaining proper brain fingerprinting scientific standards is necessary for accuracy and validity.

Researchers who have applied alternative techniques that failed to meet the brain fingerprinting scientific standards have reported lower accuracy and also susceptibility to countermeasures. Rosenfeld et al.'s (2008) alternative method does not meet the brain fingerprinting scientific standards, is less accurate – in some studies Rosenfeld reports no better than chance accuracy – and is susceptible to countermeasures. Moreover, it is unusable in the field due to two fatal flaws in the experimental procedures.

Brain fingerprinting is not only highly accurate, it is also highly resistant to countermeasures. No one has beaten a brain fingerprinting test with countermeasures, despite real-world judicial consequences and a $100,000 reward for doing so.

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Appendix 1: Differences between Miyake et al. (1993) and Farwell's Brain Fingerprinting

Farwell stated in his testimony in the Harrington case (*Harrington v. State*, 2001) that Miyake et al.'s (1993) methods were different from brain fingerprinting. The relevance of this is that since they were using different methods, the reported inaccuracy of Miyake et al.'s methods has no bearing on the accuracy of brain fingerprinting.

Rosenfeld (2005) cited the reported inaccuracy of the methods Miyake et al. (1993) as evidence that that brain fingerprinting must also be inaccurate. He selectively quoted from Farwell's testimony in the Harrington case (*Harrington v. State*, 2001). Rosenfeld falsely characterized Farwell's testimony regarding Miyake et al. (1993) as "erroneous and misleading" (Rosenfeld, p. 25).

An examination of the facts regarding the Miyake et al. (1993) article and Farwell's relevant testimony in *Harrington v. State* (2001) reveals the following facts:

1. Miyake et al.'s (1993) methods are substantially different from Farwell's brain fingerprinting;

2. Miyake et al. (1993) did not use brain fingerprinting protocols, did not meet brain fingerprinting scientific standards, and in fact failed to follow adequate scientific protocols to obtain accurate and reliable results;

3. Farwell's testimony was truthful and accurate; and

4. Rosenfeld's (2005) characterization of Farwell's testimony as "inaccurate and misleading" is false and has no basis in fact.

Farwell pointed out in his testimony in the Harrington case (*Harrington v. State*, 2001) that the Miyake et al. (1993) study has numerous serious methodological flaws, and numerous differences from brain fingerprinting.

Among the most salient are the following. Miyake et al. (2003):

1. Did not record from the scalp site (Pz) that is applied in brain fingerprinting and has been shown in over a thousand published studies to be the place where the P300 is maximal. They recorded from another site (Cz) (*Harrington v. State*, 2001, pp. 127-128).
2. Classified responses on the basis of "subjective" "visual inspection," unlike brain fingerprinting, which computes determinations and statistical confidence on the basis of an objective mathematical algorithm (Miyake et al., p. 131).
3. Attempted to detect "whether the subject is lying or not" on the basis that "deceptive subjects show different responses to stimuli" (Miyake et al., p. 131). This contrasts with brain fingerprinting, which detects information, not lies. A subject neither lies nor tells the truth during a brain fingerprinting test, but simply views stimuli and pushes buttons as instructed. The results of a brain fingerprinting test are the same whether a subject falsely or truthfully admits or denies having committed the crime.
4. Recorded an insufficient number of trials for clear determination, particularly in a field test. They used less than 10% of the number of trials that Farwell used in the brain fingerprinting test on Terry Harrington that was ruled admissible in the trial (Miyake et al.; *Harrington v. State*).

5. Use timing characteristics that are outside the range used in brain fingerprinting and over a thousand other studies involving P300 (Farwell & Donchin, 1991; *Harrington v. State*; Miyake et al.).
6. Use undefined terms and inadequately defined terms in reporting their results, including "discriminative, indiscriminative, inconclusive, and incomplete" (Miyake et al., p. 144).
7. Failed to use well-known standard methods, or any method, for artifact rejection or correction, resulting in inadequate data for accurate analysis or conclusions (Farwell & Donchin, 1991; Miyake et al., 2003).

The first sentence in the abstract of the Miyake et al. (2003) article stated: "Several polygraph examinations were undertaken to detect information which indicates whether the subject is lying or not" (p. 132). The authors state that "deceptive subjects show different responses to stimuli" (p. 132).

Brain fingerprinting does not involve detecting whether a subject is lying or not. Brain fingerprinting does not measure any such "deceptive" responses to stimuli. In a brain fingerprinting test, subjects are given a list of target stimuli and instructed to press one button in response to targets and another button in response to all other stimuli. "All other stimuli" includes both irrelevant stimuli and probes that are relevant to the crime. If the probes, like the targets, elicit a P300 and/or P300-MERMER, this indicates that the subject recognizes the probes as significant in the context of the crime. This result is the same whether the subject lies or tells the truth at any time about his participation in the crime at any time. Subjects neither lie nor tell the truth during the test. They simply view stimuli and push buttons as instructed. Clearly, whatever Miyake et al. (1993) did is fundamentally different from brain fingerprinting.

The second sentence of the abstract is: "The purpose of this report is to assess whether the event-relative (sic) potentials (ERP) method provides a competent means of identifying concealed information…" The fact that the authors do not know the correct term for event-related potentials does not speak well for their expertise on the subject. The study in question has many additional methodological flaws and substantial differences from brain fingerprinting, a few of which are summarized below.

Data were recorded from the Cz (midline central) scalp site. Miyake et al. (1993) state that this choice is because in a previous study they "compared a total of three ERPs induced from various brain regions and concluded that ERPs responses at Cz were more sensitive than other different regions on brain recorded" (p. 132). Over a thousand studies in the scientific literature have proven beyond any doubt that the P300 is maximal at the Pz (midline parietal) scalp site. The fact that the authors did not record P300 from the proper place on the scalp, and were apparently unaware of the thousands of studies demonstrating the proper site, does not speak well for their expertise on the subject. More importantly, recording at Cz is virtually certain not to provide as accurate results as recording the P300 from Pz where it is maximal.

Miyake et al. (1993) recorded only 120 trials, including 20 probes. As discussed above, this is an insufficient number of trials to provide a sufficient level of signal-to-noise enhancement through signal averaging to obtain accurate results in a field study. For example, in the

Harrington test that was ruled admissible in court, (*Harrington v. State*, 2001), Farwell presented 1,728 trials of which 288 were probes, more than ten times as many as Miyake et al.

Miyake et al. (1993) stated, ”Visual inspection of ERP waveforms often reveals differences between presented items regarding details of a crime. The final decision by ERP method results…is deemed to be subjective in so far as it requires visual inspection of waveforms” (p. 131).

In a brain fingerprinting data analysis, a mathematical algorithm is applied to the data to compute a determination of “information present” or “information absent” and a precise statistical confidence for this determination. The determination does not depend on subjective judgments by the experimenter. Miyake et al. (1993) did not use this objective data-analysis method applied in brain fingerprinting, or any objective analysis method. The authors did not define the criteria for the subjective judgments on the basis of which they classified the responses. Obviously, this is a fundamentally different procedure than the objective data-analysis method applied in brain fingerprinting.

Miyake et al. (1993) report that “each stimulus was presented for visual ERP for 250 milliseconds with a 90-millisecond inter-stimulus interval, or through a headphone for auditory ERP for 1000 milliseconds with a 1850-millisecond inter-stimulus interval” (p. 134). A 90-millisecond inter-stimulus interval is too short to obtain meaningful data. No other authors, among over a thousand published studies on the P300, have used such a short inter-stimulus interval. (This may be a misprint, and inspection of the various apparently contradictory figures does not provide a clear picture of the time course parameters used.) A 1000-millisecond stimulus duration is too long for reliable elicitation of an ERP that has a latency of 300 milliseconds. Again, such a stimulus duration well outside the range of what has been utilized by other experimenters.

In reporting their results, Miyake et al. (1993) state “diagnosis of ERP waveforms includes discriminative, indiscriminative, inconclusive, and incomplete” (p. 144). They do not adequately define these terms. This makes it difficult if not impossible to compare with brain fingerprinting results or other published studies.

In brain fingerprinting and other standard event-related potential research, experimenters use adequate methods to deal with artifacts without losing the data for an entire subject. There are well known methods for removal or correction of eye-movement artifacts. (Eye movements generate electrical potentials that interfere with the brainwaves being measured.) The authors did not use these methods. Consequently, data for 22% of the subjects were sufficiently contaminated by eye-movement artifacts and/or other artifacts to be unusable, in the subjective judgment of the authors.

The following is the entirety of Farwell’s testimony on Miyake et al. (2003) in *Harrington v. State*, (2001). (pages 127 – 128).

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Q Okay. *Are* you familiar with the study done by Miaki [sic]
published in 1993?

A Where was it published?
Q I will show you what has been marked Exhibit 8.
A Yeah. This -- Did you have a question about this?
Q Looks like -- correct me if I'm wrong – Miaki [sic] uses the same technique looking at a P300 response; correct?
A I don't know. I haven't read it. Let me read it. I will give you an idea whether it's using something even remotely similar. The first two sentences define it as being fundamentally different from what I do. "Several polygraph examinations were conducted to detect information which indicates whether a subject is lying or not" Technology I use has nothing to do with whether they are lying or not.
Q And the ERP was used to check it; right, if you want to read on?
A No. It's fundamentally different. They recorded from Cz. Cz is not the area of the head where the P300 is maximal, so I don't know what they were measuring, but it wasn't what we were measuring.
Q Was a P300 they were using?
A If they are using a P300, they are measuring it from Cz. Then they haven't read at least four or five hundred studies

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in the scientific literature indicating that is the wrong place to measure it from.
Q On Page 133 there, they mentioned that this test is based on Farwell and Donchin.
A Okay. In order to comment fully on what kind of an imitation they did of our work, I would have to read this in detail, but from superficial examination, it appears they

were doing something that was in no way related to what we did.
Q Would you be surprised that they found 44 percent accuracy?
A If they were measuring the P300 from the wrong place on the head, I wouldn't be surprised at any level of accuracy.
Q In detecting whether or not these actual criminal suspects were guilty or not?
A No. They are clearly measuring something different from what we measure, and I can't predict their accuracy rate. I also don't see where this was published, if anywhere. It was done in Japan, apparently.

Rosenfeld (2005) selectively quoted Farwell (*Harrington v. State*, 2001) as follows:

"They recorded from Cz, so I don't know
what they were measuring . . . it appears they were doing
something that was in no way related to what we did."

Rosenfeld then stated: "This statement seems erroneous and misleading, in that Miyake et al. were indeed conducting related research, as they actually cited Farwell and Donchin (1991) as the basis of their effort" (p. 25).

The first part of Rosenfeld's (2005) quotation of Farwell's testimony is from Harrington v. State (2001) page 127, lines 19 – 20. Rosenfeld leaves out part of the sentence quoted, without replacing it with ellipses. The second phrase Rosenfeld quotes, after the ellipses, is from page 128, lines 7 – 8. In the intervening testimony not quoted by Rosenfeld, and in the testimony that precedes the first phrase Rosenfeld quoted, Farwell further explains and qualifies his statement "…. it appears they were doing something that was in no way related to what we did" (p. 128).

Farwell's complete sentence was, "In order to comment fully on what kind of an imitation they did of our work, I would have to read this in detail, but from superficial examination, it appears they were doing something that was in no way related to what we did." (*Harrington v. State*, 2001, p. 128). Farwell points out in on page 127, lines 12 – 16 a fundamental difference between Miyake et al.'s (1993) methods and brain fingerprinting, in addition to the difference in location on the head from where the brainwaves are measured, namely that Miyake et al. are attempting to detect lies. The fundamental difference between brain fingerprinting and lie detection is discussed in detail above.

Miyake et al. (1993) cited Farwell and Donchin (1991) as well as half a dozen other previous studies, including two previous studies by Miyake and colleagues. Contrary to Rosenfeld's

(2005) statement, they did not state that Farwell and Donchin's work was the "basis of their effort" (p. 25). Many authors have cited Farwell and Donchin's seminal work, but that does not mean that all of them are doing the same thing as Farwell and Donchin.

Taken in context, and in light of the details of the differences between the Miyake et al. (1993) study and brain fingerprinting described above, Farwell's sworn statement (Harrington v. State, 2001) is reasonable, accurate, and truthful. Rosenfeld's (2005) characterization of Farwell's testimony as "erroneous and misleading" (p. 25) is false.

More generally, many other researchers cite Farwell and Donchin's (1991) seminal publication on brain fingerprinting. Citing a seminal work does not necessarily raise the work of a later experimenter to the same level. Many subsequent experimenters have cited Farwell and nevertheless failed to meet the brain fingerprinting scientific standards or to achieve results that approach the proven accuracy of brain fingerprinting. When other researchers such as Miyake et al. (1993) cite Farwell's work in their reports on other, non-brain fingerprinting techniques that fail to meet the brain fingerprinting scientific standards, and then go on to report inaccurate results, this proves nothing except that their alternative techniques and their failure to meet the brain fingerprinting scientific standards produced inaccurate results. This is not a reflection on the accuracy and reliability of brain fingerprinting. The accuracy and reliability of brain fingerprinting have been amply demonstrated by research on the actual brain fingerprinting technique, in studies that meet all of the brain fingerprinting scientific standards.

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