

TIME TO TAKE BRAIN-FINGERPRINTING SERIOUSLY? A CONSIDERATION OF INTERNATIONAL DEVELOPMENTS IN FORENSIC BRAINWAVE ANALYSIS (FBA),¹ IN THE CONTEXT OF THE NEED FOR INDEPENDENT VERIFICATION OF FBA'S SCIENTIFIC VALIDITY, AND THE POTENTIAL LEGAL IMPLICATIONS OF ITS USE IN NEW ZEALAND.

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I. INTRODUCTION

Any investigation into the potential legal application of a new scientific technology to legal contexts is invariably met with diverse perceptions and reactions, covering the range from adamant support, disguised bias, open-minded enquiry, cautious scepticism, outright scepticism, polite dismissal, to vehement rejection.² These reactions are amplified when the relevant technology is related to the human brain, due to well-documented differences among many credible researchers about brain functioning and the reliability of inferences that can be drawn from brain-related experiments.³

In recent years there has been an upsurge of the use of neuroscience and neuroscientific evidence in criminal investigations and criminal trials worldwide.⁴ Criminal courts have utilised various applications of neuroscience in criminal cases, including attempts at the forensic use of established medical technologies for lie detection.⁵ The scientific research of neuroscientific forensic methods has been accompanied by an increasing focus on resulting legal and ethical issues and challenges.⁶ In this regard, the 2015 US Presidential Council on Bioethics Report⁷ made three pertinent recommendations:

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¹ A list of acronyms and abbreviations is provided in Annexure A below.

² John Harris and David R Lawrence "Hot Baths and Cold Minds" (2015) 24(02) Cambridge Quarterly of Healthcare Ethics 123.

³ Feigenson N "Brain imaging and courtroom evidence: on the admissibility and persuasiveness of fMRI" (2006) 2(3) Int. J.L.C. 233 at 239.

⁴ Nita A Farahany "Incriminating Thoughts" (2012) 64(2) Stanford Law Review 351; John Bickle, Peter Mandik and Anthony Landreth "The Philosophy of Neuroscience" (26 August 2017) *The Stanford Encyclopedia of Philosophy* <stanford.library.sydney.edu.au>, O'Hara Erin Ann "How Neuroscience Might Advance the Law" (2004) 359(1451) Philosophical Transactions: Biological Sciences 1677.

⁵ Spencer J Brooks "Scanning The Horizon: The Past, Present, And Future Of Neuroimaging For Lie Detection In Court" (2013) 51 U. Louisville L. Rev. 353; Michael S Pardo "Neuroscience Evidence, Legal Culture, and Criminal Procedure" (2005) 33 American Journal of Criminal Law 301.

⁶ Martyn Pickersgill "Connecting Neuroscience and Law: Anticipatory Discourse and The Role Of Sociotechnical Imaginaries" (2011) 30(1) New Genetics and Society 27.

⁷ Gray Matters: Topics at the Intersection of Neuroscience, Ethics, and Society, 2 Op. PCSBI (2015).

- Expand and promote educational tools to aid the understanding and use of neuroscience in the legal system;
- Fund research on the intersection of neuroscience and the legal system; and
- Establish and fund multidisciplinary efforts to support neuroscience and ethics research and education.

Many law enforcement agencies in the United States of America, and in a number of other countries, have traditionally relied on the polygraph (or so-called 'lie detector')⁸ as an investigatory aid, although very few courts have been willing to admit polygraph test results as evidence in criminal trials.⁹ In addition, in the specific field of applying neuroscience to forensic investigations and lie-detection,¹⁰ there have been efforts to adapt two established medical technologies to develop new neurological methods to assist criminal investigators and courts.¹¹ These are the use of brain-scanning using functional magnetic resonance imaging (fMRI),¹² and the use of brainwave detection using the electroencephalogram (EEG).¹³ The three EEG-based forensic brainwave analysis (FBA) system applications currently in use are the Farwell Protocol, Rosenfeld's Protocol and the Brain Electrical Oscillation System (BEOS).¹⁴

*A. The NZ Law Foundation–funded FBA Project (2016 to 2017)*¹⁵

From March 2016 to March 2017, the New Zealand Law Foundation (NZLF) funded a pilot study on forensic brainwave analysis ('the FBA Project'), which had the primary objective of investigating, at a prima facie level, the reliability of Dr Lawrence Farwell's EEG- based forensic brainwave analysis technology, and the legal implications of the potential application of this technology in New Zealand. In the context of the FBA Project, this article focuses primarily on current operators who use brainwave detection using the EEG for forensic purposes (i.e. forensic brainwave detection, or FBA - sometimes also called 'brain-fingerprinting'). In addition, current projects to verify the alleged accuracy and reliability of FBA are discussed, with reference also to potential legal and ethical concerns relevant to the application of this technology.

⁸ John JB Allen "Not Devoid Of Forensic Potential, But..." (2008) 8(1) *The American Journal of Bioethics* 27.

⁹ Elton J "The polygraph in the English courts: a creeping inevitability or a step too far?" (2017) 81(1) *J. Crim. L.* 66 at 68.

¹⁰ Paul S Appelbaum "Law & Psychiatry: The New Lie Detectors: Neuroscience, Deception, And The Courts" (2007) 58(4) *Psychiatric Services* 460.

¹¹ Soren Frederiksen "Brain Fingerprint or Lie Detector: Does Canada's Polygraph Jurisprudence Apply To Emerging Forensic Neuroscience Technologies?" (2011) 20(2) *Information & Communications Technology Law* 115.

¹² Carl F. Mishler "How Functional Magnetic Resonance Imaging (fMRI) Will Change the Legal Profession" (2009) 9 *Eur JL Reform* 17; Melissa Littlefield "Constructing the Organ of Deceit: The Rhetoric of fMRI and Brain Fingerprinting in Post-9/11 America" (2009) 34(3) *Science, Technology, & Human Values* 365.

¹³ Alexandra Roberts "Everything new is old again: Brain fingerprinting and evidentiary analogy" (2006) 9 *Yale JL & Tech* 234.

¹⁴ Discussed below at II, IV, V and VII.

¹⁵ "Pilot Project: The Brain Does Not Lie: the use of Forensic Brainwave Analysis and Neuroscience in Criminal and Civil Investigations." New Zealand Law Foundation, Grant 2016/43/6. (See IX.B below.)

B. The overall aim, and structure of the article

As law enforcement and related agencies worldwide are increasingly using, or considering the use of, FBA technologies as forensic and investigative tools, an awareness of the reliability, advantages and disadvantages of these new technologies is becoming crucial. The relatively limited aim of this article is therefore to inform stakeholders in the field of law enforcement of the current status, application and potential legal implications of FBA technologies in New Zealand.

The structure of the article is as follows:

- I. Introduction;
- II. Overview of the development of forensic brain-wave analysis (FBA);
- III. The 2001 GAO Report and criticisms of Farwell's FBA methods;
- IV. Rosenfeld's Complex Trial Protocol (CTP) FBA system;
- V. The Brain Electrical Oscillation Signature (BEOS) FBA system;
- VI. The impact of the P-CAST Report (2016);¹⁶
- VII. The current scientific statuses of the Farwell, Rosenfeld and BEOS Forensic Brainwave Analysis (FBA) Systems;
- VIII. Expert evidence in support of novel scientific procedures in New Zealand;
- IX. Current projects on assessing the validity of forensic brainwave analysis;
- X. Overall conclusions.

In the next section, an overview of the development of forensic brain-wave analysis (FBA) is given, combined with an explanation of how FBA is applied in practice.

II. OVERVIEW OF THE DEVELOPMENT OF FORENSIC BRAIN-WAVE ANALYSIS (FBA)

This section commences with an overview of the pioneering FBA work of Dr Lawrence Farwell, followed by an explanation of how the FBA process works using his protocols and a consideration of three significant cases Farwell was involved in. This is followed by the United States General Accounting Office (GAO) Brain-fingerprinting Report of 2001¹⁷, and criticisms of Farwell's methodology by Professor Peter Rosenfeld,¹⁸ and Meijer and others.¹⁹

A. The development of Dr Lawrence Farwell's Brain-fingerprinting technology

The pioneer of Forensic Brainwave Analysis (FBA) was Dr Lawrence Farwell, who developed the original version of FBA with a number of collaborators during the 1980s. The term forensic brainwave analysis (FBA) refers to the general scientific technique of using the EEG to analyse P300 brainwaves for forensic purposes, and 'brain-

¹⁶ "Report to the President on Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods" OP. EOP. (September 2016) ('the P-CAST Report').

¹⁷ "Investigative Techniques: Federal Agency Views on the Potential Application of 'Brain Fingerprinting': GAO-02-22" Op. GAO. GAO-02-22 (31 October 2001). See III below.

¹⁸ Of the Department of Psychology, Northwestern University, Evanston, United States.

¹⁹ See III.B and III.C below.

fingerprinting' (BF) is a term used by Farwell. In this paper, BF refers specifically to Farwell's particular technique of FBA, being the analysis of the P300 brainwave, combined with an analysis of the MERMER²⁰ extension of the P300 brainwave, to detect the presence or absence of information in the brain.

Dr Farwell started developing brain-fingerprinting in 1985, and presented his initial research at a scientific conference in 1986. Farwell, with co-author Donchin, authored a number of peer-reviewed papers on brain-computer interfaces,²¹ and in 1991, Farwell and Donchin published the seminal peer-reviewed article on brain-fingerprinting (BF).²²

The seminal 1991 paper introduced three innovations to the Concealed Information Test (CIT), a test used to detect a person's guilty knowledge of a crime using a polygraph (also called the 'Guilty Knowledge Test'). They (1) applied a classification CIT, rather than the conventional comparison CIT; (2) used event-related brain potentials (ERPs)²³ as the dependent measure; and (3) computed a statistical confidence for each individual determination using the technique of bootstrapping.²⁴

Dr Farwell continued to research and carry out field tests of his new brain-fingerprinting technique. In doing so he refined the technique to add what he termed the 'Memory and Encoding Related Multifaceted Electroencephalographic Response' (MERMER)²⁵ to the P300 test. He discovered that after the P300 wave at 300 milliseconds after the stimulus, a little later at between 800 and 1200 milliseconds after the stimulus there was a consistent MERMER- tail produced by the brain. Using similar analyses to that used in interpreting the P300 brainwave, he used the MERMER to validate his P300 results, and increase the statistical confidence of an accurate and reliable result.²⁶

After the inclusion of the MERMER in his brain-fingerprinting analysis, Farwell reported conclusive results in all the BF cases he has tested with a statistical accuracy of 99.9%, and reported that he had never had a false positive or false negative result.²⁷

²⁰ Memory and Encoding Related Multifaceted Electroencephalographic Response.

²¹ Farwell LA and Donchin E "Event-related brain potentials in interrogative polygraphy: analysis using bootstrapping" *Psychophysiology* 25 (1988) 445; Farwell LA and Donchin E "Talking off the top of your head: toward a mental prosthesis utilizing event-related brain potentials" *Electroencephalogr. Clin. Neurophysiol.* 70 (1988) 510- 513.

²² Farwell LA and Donchin E "The truth will out: interrogative polygraphy ('lie detection') with event-related brain potentials" *Psychophysiology* 28 (1991) 531.

²³ An ERP is a measured brain response that is the direct result of a specific sensory, cognitive, or motor event stimulus, and that is measured by means of electroencephalography (EEG).

²⁴ "Bootstrapping" refers to the process of loading an initial computer code or programme, that in turn prompts the loading of subsequent computer programmes needed to effectively implement various computer-driven tasks (in this case, the brain-fingerprinting analysis).

²⁵ Patented by Dr Farwell in 1994 - see n 94 below.

²⁶ Farwell LA and Smith SS (2001) "Using brain MERMER testing to detect concealed knowledge despite efforts to conceal" *J. Foren. Sci.* 46 (2001) 135.

²⁷ Above n 26.

B. How Dr Farwell's forensic brainwave analysis (FBA) system works

Dr Farwell's "brain-fingerprinting" FBA technique initially relied on using an EEG²⁸ to detect the behaviour of the electrical brainwave known as 'P300',²⁹ followed by an interpretation of the detected brainwaves (as explained below). The P300 brainwave response is emitted from the brain as soon as the brain detects information of particular significance (within 300 milliseconds after exposure to a stimulus). This measured brain response, that is the direct result of a specific sensory, cognitive, or motor event (called the "stimulus"), and that is measured by means of electroencephalography (EEG), is called an event-related potential (ERP).³⁰

To illustrate: After being involved in a particular crime incident, there is certain information *only* a person involved in the incident would have knowledge of, and which knowledge would be stored in his or her brain (such as the number and description of items of jewellery stolen, the facial features of a victim, the exact time it happened, the weapon used, etc). The EEG is then used to detect certain P300 brainwaves that are effectively the key indicators of this unique knowledge – things that only the person involved in the incident in question would know (Farwell calls this concealed information "probes"). The essence of the FBA procedure is to detect this concealed information in the brain of the crime suspect. However, the presence of these probes in the brain of the suspect does not necessarily mean that the suspect actually committed the crime: it just means that he or she has information in their brain that only someone involved in the crime would know. For example, the suspect may have been taken to the crime scene by force, and could have been compelled by others to participate in the crime. Of course, if the suspect had, prior to the test, said that he had had no knowledge of the crime, and the FBA test results showed that he in fact *did* have such knowledge, investigators may draw the inference that he is lying about his involvement. The point is, however, that the FBA test is, in essence, a *knowledge* detector, not a *lie*-detector.

The technique relies solely on the detection and interpretation of EEG signals, and no oral or written responses are required from the subject. The responses are therefore outside the subject's control, and cannot easily be manipulated by him or her (although there is some research that suggests that it is possible to conceal guilty knowledge in FBA tests³¹). As explained in II.A above, this initial P300 test was later further developed and refined by Dr Farwell and his associates into the 'Memory and Encoding Related Multifaceted Electroencephalographic Response' (MERMER) test, in which additional features were added to the P300 test, resulting in a very high level of reported accuracy. The MERMER response follows the initial P300 detecting follow-up

²⁸ Electroencephalogram.

²⁹ The P300 brainwave was discovered by Sutton et al: Sutton S, Braren M, Zubin J, John ER "Evoked potential correlates of stimulus uncertainty." (1965) 150 Science 1187–1188.

³⁰ Koops B and others *Responsible Innovation 2* (Springer International Publishing, Switzerland, 2015) at 245; Farwell LA and others "Optimal Digital Filters for Long Latency Components of the Event-Related Brain Potential" (1993) 30 Psychophysiology 306.

³¹ Zara M Bergström and others "Intentional Retrieval Suppression Can Conceal Guilty Knowledge In ERP Memory Detection Tests" (2013) 94(1) Biological Psychology 1.

waves in the 800 to 1200 milliseconds post-stimulus range.

C. The testing methodology using Farwell's FBA protocols

Farwell's FBA testing methodology is to use a specially-designed EEG headset that contains electronic sensors that detect brainwaves. The headset is linked to desk computer or laptop computer loaded with the FBA software.

The subject is fitted with headset and is seated before another computer monitor in the same room. Various stimuli are then shown on the screen, which could include words, phrases, diagrams, pictures, or photographs. Typically a sequence of thirty to fifty stimuli is presented in a single testing, within which three types of stimulus are randomly distributed, using the so-called Oddball Paradigm.³² These three types of stimuli are:

(1) Irrelevant stimuli: called "irrelevants"- these are words, phrases, diagrams, pictures, or photographs that are *not in any way* relevant to the case being investigated, and that the subject has no prior knowledge of.

(2) Target stimuli: called "targets"- these are words, phrases, diagrams, pictures, or photographs that *are* relevant to the case being investigated and are known to the subject, either because of prior knowledge, or because this information has been disclosed to the subject before the FBA test is conducted.

(3) Probe stimuli: called "probes"- these are words, phrases, diagrams, pictures, or photographs that are relevant to the case being investigated, and that *only a person involved in the incident would know*. The probe stimuli are carefully selected items of information known *only* to the investigators and those involved incident. This information would not be known to persons not involved in the incident.

D. A Practical illustration of FBA: The Mobile Phone Theft

A demonstration used by the author in presentation seminars can be used to explain practical application of FBA, following Farwell's FBA protocols. The scenario is the simulated theft of a mobile phone belonging to the presenter of a seminar from a closed drawer in the console at the front of the auditorium. A designated member of the 50 members of the audience "steals" the phone during a ten-minute rest-room break while the presenter is outside the auditorium.

The auditorium has around 300 tiered seats, all covered with light-blue fabric. At the front of the auditorium is a brown, wooden control console, with a built-in computer and two drawers below the computer. There are red exit signs above the two entrances and two drop-down screens. Suspended from the ceiling are two remote-

³² An "oddball paradigm" is an experimental design used in psychology research, where presentations of sequences of repetitive stimuli are infrequently interrupted by a deviant stimulus. In Farwell's FBA test, subjects respond to an infrequent stimulus designated the *targets*, which are randomly embedded in a background of standard stimuli (in this case, the targets include *probes*, and the standard stimuli are the *irrelevants*.)

controlled projectors and on the left-hand wall is a large mural of a ship at sea. Behind the two drop-down screens are two white-boards and on the right-hand wall is another mural depicting a farm scene including a number of farm animals. There is a small brown wooden table with two black two chairs in the centre of the auditorium.

Inside the drawer from which the mobile phone was stolen, is a black stapler; a bunch of car keys with a silver bottle-opener attached to it; one red and one green whiteboard marker pen; a small white calculator; a blue plastic mug and, prior to the "theft," the mobile phone (which was a white iPhone 5). The base of the drawer is covered in green velvet.

In preparation for the FBA testing of the 50 suspects (being the 50 members of the audience, as the scenario assumes that one of the audience members stole the mobile phone), the tester will prepare the words and images as follows to be included in the series of items (known as "stimuli") to be shown to the subjects:

- *Irrelevants*: A number of words and images completely unrelated to the auditorium and seminar, even nonsense, made-up information. The principle here is that the irrelevant stimuli *must not* be known or recognised by the suspect.
- *Targets*: This is information that all the suspects will know, for example the images of the two murals and the console at the front of the auditorium; references to the red exit signs; references to the colour of the seats; a description of the table and two black chairs; and references to the two drop-down screens. In addition, these words, phrases and images are shown to the subject before the testing to confirm their recollection.
- *Probes*: In this case, the obvious probes (information only the perpetrator would know) would be the contents of the drawer in which the mobile phone was placed. These probes would include references to, or images of the green velvet base of the drawer; the black stapler; the bunch of car keys with a silver bottle-opener attached to it; the red and green whiteboard marker pens; the small white calculator; and the blue plastic mug.

A list of words, phrases and images (collectively called 'stimuli') is then drawn up, and the irrelevant, target and probe stimuli are randomly placed within the list. The FBA test is then administered³³ and the graphs of the brainwave responses (ERPs- P300 brainwaves and MERMERs) are subsequently analysed to determine one of three results:

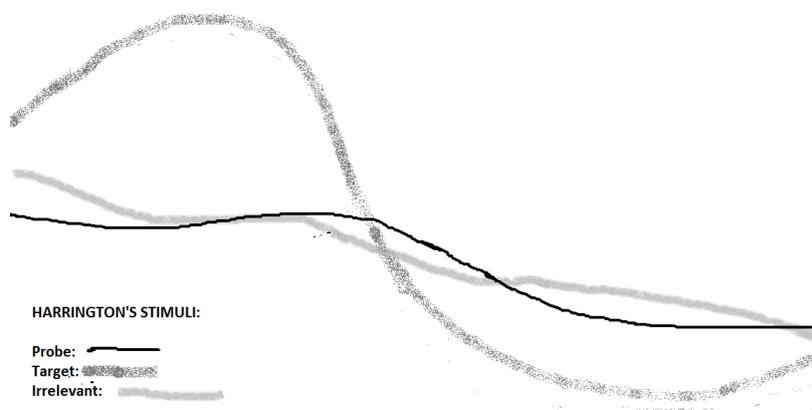
- A finding of *information present*: the FBA test indicates that the subject *does* have knowledge of the probes in his brain, and was therefore *must have* looked in the drawer); or
- A finding of *information absent*: the FBA test indicates that the subject *does not* have knowledge of the probes in his brain, and was therefore *did not* look in the drawer; or
- An *indeterminate* result: the statistical confidence in the results is not high enough to make a definite finding.³⁴

³³ The testing methodology description is obviously a simplification of the testing process, as a single test takes up to three hours to complete, and entails numerous repetitions of the test that are averaged to get a valid result.

³⁴ Farwell claims to have not produced any indeterminate testing results since the introduction of the MERMER component to his FBA testing. Further, Farwell claims he has had no false negative or false

Represented graphically, an “information present” result shows as a peak or spike, and an “information absent” result typically has a flatter trajectory. The test results of the 49 subjects who did *not* open the drawer would typically show the *targets* as a spiked P300 brainwave (recognised by the brain as “information present”), and the probes’ brainwave matching the irrelevant’s brainwave (with a generally flatter trajectories due to no brain recognition- “information absent”). The depiction of this result would be similar to the Harrington Case³⁵ brainwave chart extract below, where the *probes*’ brainwave tracks the *irrelevant’s* brainwave, as both these categories of stimuli are not recognised by the brain. The *targets*, which *are* recognised, shows as a P300 peak or spike (Figure 1):

Figure 1- Probes information absent:



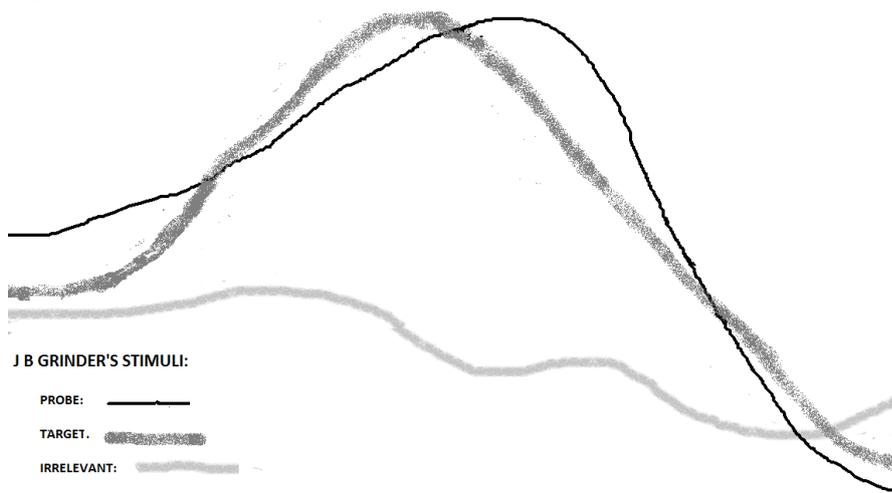
One the other hand, if we assume that the FBA test of one member of the audience (let’s call him John Doe) shows the *probes* brainwave tracking the *targets* brainwave, this indicates that John Doe indeed *does have* knowledge of the probe objects that were inside the drawer. This, of course, does not mean that he stole the mobile phone: it just means that he had opened and looked into the drawer. This information then calls for an explanation from him as to when and why he looked inside the drawer, and may assist with an ultimate conclusion that he is probably the thief. John Doe’s brainwave would look similar to the Grinder Case³⁶ FBA graph extract below (Figure 2):

positive results in any of the studies he has done: see Farwell LA, Richardson DC, Richardson G “Brain fingerprinting field studies comparing P300-MERMER and P300 ERPs in the detection of concealed information” (2011) 48 Psychophysiology 95.

³⁵ Discussed at II.E.2 below.

³⁶ Discussed at II.E.1 below.

Figure 2- Probes information present.



Three significant cases in which Dr Farwell's brain-fingerprinting ("BF") FBA testing technology was applied are discussed next, starting with the case of J.B. Grinder in 1999.

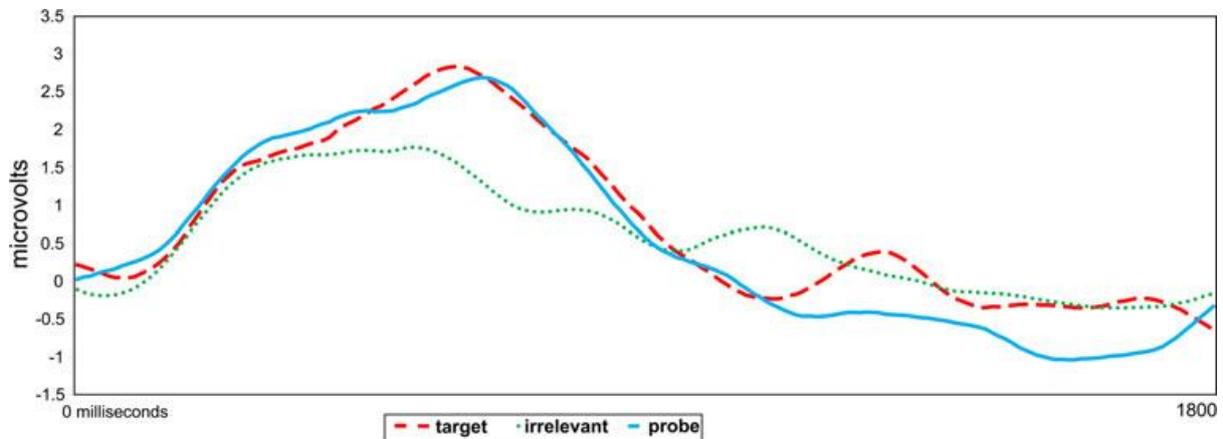
E. Three significant FBA cases: Grinder, Harrington and Slaughter

1. The J B Grinder Case (1999)

In January of 1984, Julie Helton's body was found near the railroad tracks in Macon County, Missouri, in the United States. She had been raped and beaten, and then stabbed to death. For over 15 years (as at 1999), JB Grinder had been the primary suspect in this murder, but had never been charged due to the lack of sufficient evidence to take the case to trial.

Eventually the Macon County Sheriff approached Dr Farwell to use FBA testing to assist in the investigation. On August 5, 1999, Dr Farwell administered a brain fingerprinting (BF) test on JB Grinder. Drew Richardson, then a scientist in the FBI Laboratory, was the criminal investigator who identified and formulated the probe stimuli. The BF test applied indicated that Grinder contained specific details of the crime in his brain with a statistical confidence of 99.9%. Following the brain fingerprinting test results, corroborated by other evidence, Grinder pleaded guilty to the rape and murder of Julie Helton in exchange for a sentence of life in prison without the possibility of parole. He is currently serving his life sentence. In addition, Grinder later confessed to the murders of three other young women, Teresa Williams, Crystal Parton and Cynthia Mabry.

Figure 3: J.B. Grinder's brainwave graph. The *probes* brainwave line (blue solid line) closely matched the target information line (red, bold broken line), showing specific knowledge of the crime is present and guilt can be inferred. The bottom flatter green dotted line indicates the irrelevant.



2. The Terry Harrington Case (2001)

In many respects the Terry Harrington case in the United States is very similar to the Teina Pora case in New Zealand.³⁷ Both Harrington and Pora were wrongly convicted as 17 year-olds: both were charged with murder; both were convicted on the evidence of young witnesses improperly influenced by police investigators, and both spent more than 20 years in prison. The catalyst for Harrington's eventual release was the intervention of Dr Farwell and Harrington's exonerating brain-fingerprinting test, whereas Pora would undoubtedly still be imprisoned had it not been for a tenacious ex-policeman investigator who was convinced of his innocence.³⁸

Terry Harrington was accused of the murder of John Schweer, a retired police captain who was employed as a security guard at a car dealership in Iowa, United States. Schweer was murdered in the early hours of the morning of July 22nd 1977. During the police investigation, Kevin Hughes, a young acquaintance of Harrington's, was arrested, and after giving a number of false statements, Hughes eventually claimed that Terry Harrington, along with another 17 year old named Curtis McGhee, had attempted to steal a car from the premises Schweer was guarding on the night of the murder. Hughes alleged Harrington had shot Schweer when the latter came to out to investigate the attempted theft. This resulted in Harrington being convicted of murder in a jury trial in August 1978. He was sentenced to life imprisonment without parole. Harrington always maintained his innocence, and that he had an alibi for the night of the murder. After spending 24 years in prison, and after numerous failed court applications and appeals over the years, Harrington's lawyer, as a last resort, arranged for Harrington to be FBA tested by Dr Lawrence Farwell.

³⁷ *Pora v The Queen* [2015] UKPC 9.

³⁸ Michael Bennett *In Dark Places: The Confessions of Teina Pora and an Ex-cop's fight for Justice* (Paul Little Books, Auckland, 2016).

On April 18 and 25, 2000, Dr Lawrence Farwell administered a brain fingerprinting test to Harrington. The test results demonstrated that Harrington's brain did not contain a record of certain specific salient features of the crime ("probes"). Then Harrington's alibi was tested, and this test showed that he *did* recognize the salient details of his alibi. The result was therefore "information absent" with respect to the crime, and "information present" with respect to the alibi, in both cases with a statistical confidence of 99.9%.³⁹

When Dr Farwell confronted the key trial witness Kevin Hughes with the brain fingerprinting test results, Hughes admitted that he had lied about Harrington and McGhee's involvement in Schweer's murder. He said he had falsely accused Harrington and McGhee under extreme police pressure, and to avoid being prosecuted himself. He was also paid a \$5 000 reward by the police authorities.

In *Harrington v State*⁴⁰ in 2001, in an Iowa district court, Harrington sought to overturn his murder conviction on several grounds, including reliance on "newly discovered evidence" in the form of Farwell's brain fingerprinting results.

Dr Farwell testified as an expert witness in this trial, and after an eight-hour admissibility hearing, the court found the Farwell's BF evidence was admissible by applying the *Daubert* principles. The Court held, in particular, that the P300 brainwave science in general was well-established and widely accepted.⁴¹ However, the High Court nevertheless denied the motion for a retrial, and Harrington appealed to the Iowa Supreme Court in 2003.⁴² The Iowa Supreme Court relied on the violation of Harrington's constitutional rights by the police to overturn his murder conviction, but did not deal with the reliability or accuracy of Farwell's brain fingerprinting evidence. Harrington was released, together with his erstwhile co-accused, Curtis McGee. Harrington was paid \$7.03 million, and McGhee \$4.97 million in compensation.⁴³

Although the Iowa courts in the Harrington cases were not prepared to overtly rely on the FBA technology evidence, the brain-fingerprinting test results played a pivotal role in the sequence of events that led to Harrington's eventual release. In particular, Kevin Hughes, who admitted when confronted by Dr Farwell after Harrington's FBA tests that he had falsely implicated Harrington, filed an affidavit in the 2003 appeal case admitting his false testimony.

³⁹ See Harrington's FBA graph: Figure 1 above.

⁴⁰ *Harrington v State*. Case No. PCCV 073247 (Iowa District Court for Pottawattamie County, 5 March 2001).

⁴¹ *Daubert v Merrell Dow Pharmaceuticals* 54 APP. D.C., at 47, 293 F.

⁴² *Harrington v State*. 659 N.W.2d 509 (Iowa 2003).

⁴³ Denzel S and Possley M "Terry Harrington" (17 August 2017) The National Registry of Exonerates <www.law.umich.edu>, Farwell LA "Farwell Brain fingerprinting Helps to Free an Innocent Man" (17 August 2017) Farwell Brain Fingerprinting <<http://www.larryfarwell.com>>.

3. The Jimmy Ray Slaughter case (2005)

In 2004, Dr Farwell administered an FBA test on Jimmy Ray Slaughter, a death-row inmate in Oklahoma, in support of a petition for post-conviction relief. Slaughter had been convicted in 1994 of murdering his ex-girlfriend and her young daughter, but had consistently and vehemently denied his guilt.

The Oklahoma Court of Appeals declined to order an evidentiary hearing on numerous issues raised by Slaughter.⁴⁴ The submitted application included an “information-absent” result for crime-scene *probes* on the brain fingerprinting test administered by Farwell, indicating that Slaughter had no knowledge of the crime – scene *probes*. Despite this, and despite compelling exculpatory DNA evidence, the court dismissed the application, which also included the sworn testimony of the original lead investigator of the case in which he stated that he had come to believe that Slaughter was innocent, and credible evidence that persons involved in the investigation had falsified reports and fabricated evidence against Slaughter. Slaughter was subsequently executed in May 2005.⁴⁵

III. THE 2001 GAO REPORT AND CRITICISMS OF FARWELL’S FBA METHODS

The startling level of reported accuracy of Dr Farwell’s FBA methods has attracted a number of critics, the most prominent being Professor Peter Rosenfeld of Northwestern University, and Ewout Meijer and others. Before considering these criticisms, the 2001 report on brain-fingerprinting by the US General Accounting Office (GAO), which Rosenfeld contributed to, is discussed.

*A. The US Government Accountability Office (GAO) Brain-fingerprinting Report (2001) (“GAO Report”)*⁴⁶

The GAO Report is a brief report, prepared by the United States Government Accountability Office in 2001, outlining the views of the FBI, U.S. Secret Service, and several scientists on the use of brain-fingerprinting (BF) as a potential forensic investigative tool. After outlining what the technique is and how it works, the report considered some of the concerns the FBI had with the use of BF, followed by comments on BF by selected scientists, including Professor Peter Rosenfeld. The main criticism of BF was the lack of independent field research and trials, leading to a lack of confidence in the technique due to insufficient scientific evidence to demonstrate the validity and reliability of BF techniques. Some of the critics recognised that initial BF results were promising, but that the lack of field research was a real concern. This lack of field trials led to a secondary concern that there was no research on the effect of drugs or alcohol on the memory in relation to the use of BF.

⁴⁴ *Slaughter v State* WL 562759 (Okla.Cr.App 2005) (3rd PCR).

⁴⁵ On an ancillary note, it may be interesting research to investigate whether the psychological impact of Slaughter’s unfortunate surname had any unconscious influences on the court’s decision.

⁴⁶ “Investigative Techniques: Federal Agency Views on the Potential Application of ‘Brain Fingerprinting’: US Government Accountability Office 02-22” Op. GAO. GAO-02-22 (31 October 2001).

The FBI's earlier view in 1993, that the BF technique would not be useful as an investigative tool as the benefits gained did not outweigh the costs, was also discussed. Two FBI agents who had conducted research with Dr Farwell disagreed with this conclusion, and claimed that it could be a useful investigative tool for the FBI. They stated, however, that this would require intensive new training to ensure that the collection of information at crime scenes would be specific enough for the technique to be properly employed (to ensure, for example, that reliable and confidential *probes* were identified at an early stage of the investigation).

This report was produced in 2001, and the FBI's 1993 views have since been superseded to some extent by later FBA studies Dr Farwell conducted in 2008. Farwell's work with the FBI (and CIA) in 2008 was restricted from publication for a number of years, and four field studies that were conducted with the FBI and the CIA were finally published in 2013.⁴⁷ Following the publication of these studies, Farwell and others published a further study in 2014 which was funded by the CIA and conducted at the US Navy. Farwell reported that this study produced the same results as the BF studies published in 2013, with 0% error rates and 99.9% statistical confidence levels, with no false negatives, false positives or indeterminate results.⁴⁸

B. Rosenfeld's critique of Farwell's Brain-fingerprinting Procedure

In 2005, Professor Peter Rosenfeld attempted to replicate the studies of Dr Farwell, and published a critique of Farwell's work.⁴⁹ Rosenfeld criticised several aspects of Farwell's work, including citing the GAO Report, to which he contributed.⁵⁰ Rosenfeld reiterated concerns present in the GAO Report about the practical application of the technology as well as raising concerns about the completeness of the research. He called for further field tests and more peer-review of Farwell's research, but conceded that the research showed promise. Rosenfeld also attempted to replicate Farwell's tests in a series of studies, and did not achieve accuracy rates as high as Farwell's. In fact, Rosenfeld achieved accuracy as low as 54% in some studies. This led him to the conclusion that Farwell's brain-fingerprinting protocol was not as accurate as Farwell claimed in his research papers.

Farwell's response to this was that Rosenfeld had mistakenly applied the generalised susceptibility to countermeasures of certain non-brain fingerprinting techniques Rosenfeld had studied, to Farwell's brain-fingerprinting techniques. In particular, Farwell claimed that Rosenfeld did not follow the correct methodology laid out in Farwell's "Brain Fingerprinting Scientific Standards: Scientific Standards for Brain

⁴⁷ Farwell LA, Richardson DC and Richardson GM "Brain fingerprinting field studies comparing P300-MERMER and P300 brainwave responses in the detection of concealed information" (2013) 7 Cogn. Neurodyn. 263.

⁴⁸ Farwell LA, Richardson DC, Richardson GM and Furedy JJ "Brain fingerprinting classification concealed information test detects US Navy military medical information with P300" (2014) 8 Front. Neurosci. 410.

⁴⁹ Rosenfeld JP "Brain fingerprinting: a critical analysis." (2005) 4 Sci Rev Mental Health Practice 20.

⁵⁰ Above n 46.

Fingerprinting Tests,” and asserted that had Rosenfeld followed these standards, he would have achieved a much higher accuracy rate, and would have found countermeasures to be ineffective.⁵¹

C. Meijer and others’ critique of Farwell’s Brain-fingerprinting Procedure

The other major critique of Farwell’s work was by Ewout Meijer and others in 2013.⁵² Responding to Farwell’s 2012 article,⁵³ the essence of their critique was that Farwell’s hypothesis that relevant stimuli (including the *probe* stimuli) will elicit an enhanced P300 response only in participants who have the concealed information present in their brains was misleading and not scientifically valid. They argued that the research indicates that any event that violates the tested subject’s expectations would elicit a P300 response. They also criticised Farwell’s MERMER test, arguing that the MERMER test does not add any incremental validity beyond the P300 alone. (It should also be mentioned that the authors suggest that Farwell patented his MERMER test in 1994 to overcome the restriction on use of the P300 CIT protocol for FBA knowledge detection, as the latter patent is held by the University of Illinois, and was the protocol used in experiments described in Farwell and Donchin’s seminal 1991 paper.) Significantly, Farwell’s erstwhile co-author, Donchin, was also one of the co-authors of the Meijer et al critique. This apparent animosity appeared to be confirmed by the title of Farwell and Richardson’s reply in 2013 to the Meijer et al critique, in which the scientific criticisms raised were responded to.⁵⁴

Professor Peter Rosenfeld also developed his own forensic brain-wave tests and protocols, named the Complex Trial Protocol (CTP), and described the CTP protocols in a paper published in 2008.

IV. ROSENFELD’S COMPLEX TRIAL PROTOCOL (CTP) FBA SYSTEM

In 2008, Rosenfeld and his co-authors published a description of his Complex Trial Protocol (CTP) FBA system.⁵⁵ In essence, the CTP protocol is a concealed information test (CIT) where a selected probe or frequent irrelevant stimulus appears in the same trial in which a target or non-target later appears. A later second stimulus then appears: target or non-target. The subject presses one button for a target, another for a non-target. A P300 brainwave response to the first stimulus indicates probe recognition. One group was tested for denied recognition of familiar information,

⁵¹ Farwell LA “Brain fingerprinting: Corrections to Rosenfeld” (2011) 8 *Sci.Rev. Mental Health Pract.*56.

⁵² Ewout H Meijer, Gershon Ben-Shakhar, Bruno Verschuere, Emanuel Donchin “A comment on Farwell (2012): Brain fingerprinting - a comprehensive tutorial review of detection of concealed information with event-related brain potentials” (2013) 7 *Cognitive Neurodynamics* 155–158.

⁵³ Farwell LA “Brain Fingerprinting: a comprehensive tutorial review of detection of concealed information with event-related brain potentials” (2012) 6 *Cong. Neurodyn* 115 at 129.

⁵⁴ Farwell LA and Richardson DC “Brain fingerprinting: let’s focus on the science- a reply to Meijer, Ben-Shakhar, Verschuere, and Donchin” (2013) 7 *Cogn Neurodyn* 159- 166.

⁵⁵ Rosenfeld JP and others “The complex trial protocol (CTP): a new countermeasure resistant accurate P300-based method for detection of concealed information.” (2008) 45 *Psychophysiology* 906.

followed by testing to control for attempted countermeasure (CM) conditions. The results were positive, with a reported statistical confidence result of more than 90% in identifying probe recognition.

Rosenfeld's reasonably impressive recognition results using his CTP protocol appears to have been substantively independently replicated in laboratory conditions by Lukács and others in 2016.⁵⁶

Apart from the Farwell and Rosenfeld FBA protocols, a third variant of FBA testing has been developed in India, called the Brain Electrical Oscillation Signature (BEOS) system. This FBA method has been fairly widely used by investigators in India, and also by certain organisations outside India, like the Ministry of Home Affairs (MHA) in Singapore.

V. THE BRAIN ELECTRICAL OSCILLATION SIGNATURE (BEOS) FBA SYSTEM

The Brain Electrical Oscillation Signature (BEOS) system (also called Brain Electrical Activation Profile (BEAP)) is a variant form of FBA, and was developed by Champadi Raman Mukundan, a former professor of psychology at Bangalore's National Institute of Mental Health and Neuro Sciences ("NIMHANS"). During the years 2000 to 2010, BEOS was used in parts of India in criminal pre-trial investigations, and reportedly in a number of criminal trials as well. The BEOS system was used primarily by police and prosecutors, together with the polygraph and narco-analysis,⁵⁷ as tools of criminal investigation.⁵⁸

The operation of the Brain Electrical Oscillation Signature (BEOS) system, is described by its developers as follows:⁵⁹

BEOS is a non-invasive supporting tool that can aid law enforcement officers to investigate whether a suspect is involved in any unlawful activities. The BEOS system detects the retrieval of memories related to Experiential Knowledge (EK) in the human brain. Individuals acquire EK after carrying out a task/activity or being present at an event. EK contains neural components that are related to emotions, sensory-motor activities and proprioceptive sensations. In contrast, conceptual knowledge is acquired if individuals read about an event in the newspaper or book. The conceptual knowledge lacks the experiential components and represents the "knowing" system of the brain.

The BEOS result is analysed and automatically generated by the proprietary BEOS algorithm. It

⁵⁶ Gáspár Lukács, Béla Weiss, Vera Daniella Dalos, Tünde Kilencz, SzabinaTudja, GáborCsifcsák, "The first independent study on the complex trial protocol version of the P300-based concealed information test: Corroboration of previous findings and highlights of vulnerabilities." (2016) 110 *International Journal of Psychophysiology* 56–65.

⁵⁷ A psychotherapy procedure whereby the subject is put in a sleep-like or semi-conscious state induced by drugs such as Midazolam, Flunitrazepam, Sodium thiopental, and Amobarbital (all colloquially known as 'truth serum'). In this semi-conscious state, the subject gives information, often incriminating him- or-herself.

⁵⁸ Suresh Bada Math "Supreme Court judgment on polygraph, narco-analysis & brain-mapping: A boon or a bane?" (24th August 2017) National Centre for Biotechnology Information <ncbi.nlm.nih.gov>.

⁵⁹ There appears to be no other literature readily available that explains the BEOS FBA system.

is based on complex time frequency and temporal spatial signal changes that takes place in the brain. Hence, it does not require visual inspection of waveforms by the user.

The BEOS technology has no relation to the Brain Fingerprinting - P300 Mermer testing, and is not based on a single potential⁶⁰. The P300 Mermer is only based on the basic P300 signal averaging occurring at 300 milliseconds and used in routine lab ERP tests. However, the BEOS technology tracks neural processes related to memory retrieval through various stages including sensory registration, primary processing, encoding, and finally experiential knowledge. The retrieval of EK can be triggered by reminding the person of interest about the task/event. The retrieval process is stimulated by presenting a series of customised sequential auditory sentences (probes) that is related to the task/event.

Probes are classified into 3 different categories:

- Neutral Probes – Not associated with any memories and are used as baseline;
- Control Probes – Related to established facts about the person being screened;
- Target probes – Related to the event being tested. Target probes are presented in two parts, being the details of the event hypothesised by the investigating officer, and the account of the event given by the subject.

During the presentation of the time locked auditory probes to the subject, the BEOS technology records the brainwave signals across 30 locations on the scalp. The proprietary BEOS algorithm analyses the recorded brainwave data to identify neural signatures related to EK for each auditory probe presented. The algorithm auto generates the BEOS result and flags out those probes that have triggered the retrieval process of Experiential Knowledge (EK).⁶¹

Apart from the BEOS developers' description above, there appears to have been no independent replications of the BEOS system protocols done or published to date.⁶²

The next question that will be considered is the extent to which the Farwell, Rosenfeld and BEOS forensic brainwave analysis (FBA) systems are considered sufficiently reliable and accurate to be used in civil and criminal investigations, or as expert evidence in civil and criminal court proceedings. The recently released P-CAST Report provides useful guidance for an acceptable standard of scientific validity in this regard.

VI. THE IMPACT OF THE P-CAST REPORT (2016)⁶³

The Report to the President on Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods ("the P-CAST Report") was written to critique the current use of established scientific forensic techniques in police investigations and court proceedings in the United States. Although the report's focus is on the United

⁶⁰ Event-related Potential (ERP).

⁶¹ Champadi R. Mukundan, Nilesh B. Wagh, Gunjan Khera, Shraddha U. Khandwala, Tara L. Asawa, Namrata M. Khopkar, Dharmistha D. Parekh (2008) "Brain Electrical Oscillations Signature Profile of Experiential Knowledge." Directorate of Forensic Sciences, Gandhinagar, Gujarat, India 1–45.

⁶² Puranik, D.A., Joseph, S.K., Daundkar, B.B., Garad, M.V. (2009) "Brain Signature profiling in India. It's status as an aid in investigation and as corroborative evidence – as seen from judgments." Proceedings of XX All India Forensic Science Conference, November 15 – 17, Jaipur. 815–822.

⁶³ "Report to the President on Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods" OP. EOP. (September 2016) ('the P-CAST Report').

States, its contents and conclusions are relevant to all countries where similar techniques are used, including the UK and New Zealand.⁶⁴

The report focuses on the accuracy and reliability of a number of established forensic techniques, and criticises many current practices for inadequate accuracy rates. However, forensic brainwave analysis (FBA), and other concealed information tests such as the polygraph and fMRI are not dealt with, and are only mentioned in passing:

We believe this report should encourage the legal community to require that the emerging field of forensic neuroimaging, including fMRI based lie detection, have a proper scientific foundation before being admitted in courts.⁶⁵

The report nevertheless provides valuable guidance and criteria for the further development of FBA and similar neurological forensic processes, such as fMRI.

The report strongly recommends that the courts use a two-stage procedure when assessing forensic evidence:

- First, that the forensic technique which is being employed has *foundational validity*; and
- Second, that the test being assessed in a specific case has *validity as applied*.

“Foundational validity” refers to whether a technique is scientifically sound, replicable, and accurate in a lab environment. “Applied validity” is whether a technique’s effectiveness can be used in the real world outside of a scientific setting.

The P-CAST Report’s criticism of a lack of foundation validity is based on the lack of empirical evidence of many forensic scientific techniques to support their alleged accuracy and reliability. The report categorises these scientific techniques in two ways. Either the technique is objective or subjective. The objective techniques are those which require no human analysis for drawing a conclusion. The example used in the report is simple DNA testing where there is just one or two people’s DNA in the sample that is being tested. This kind of technique only requires computer analysis of the sample and requires no human analysis to draw a conclusion.

Validity as applied refers to the need to establish validity in any given case rather than just the overall validity of the technique. Here the report considers the current approach in America where expert witnesses are not allowed to tell juries exact values of the chance of error. Instead experts are expected to use broader terminology and claim there is a chance they could be wrong rather than represent what the exact chance is.

Overall, this report raises concerns about the lack of both foundational and applied validity in the use of most forensic sciences. The report believes that peer review, estimates of accuracy, or rates of accuracy in the “perfect world” is no longer satisfactory. These estimates do not account for human error and the actual real-world accuracy of these techniques. All the proposed recommendations in the report

⁶⁴ See Tony Ward and others “Forensic Science, Scientific Validity and Reliability: Advice from America” (2017) 5 Crim.L.R. 357.

⁶⁵ Above n 63 at 4.8.

are aimed at improving reliability, as well as more accurately measuring the accuracy of techniques.

The Report also discusses concerns that juries often don't understand or have the capacity to properly evaluate complex scientific evidence; for example, appreciating the realistic chance of false positives when applying these forensic techniques.

In conclusion, given the trenchant criticisms in the P-CAST Report of many existing forensic science investigation techniques and practices, the future research and development of FBA will have to ensure that both aspects of validity, foundational and applied, are adequately addressed.

VII. THE CURRENT SCIENTIFIC STATUSES OF THE FARWELL, ROSENFELD AND BEOS FORENSIC BRAINWAVE ANALYSIS (FBA) SYSTEMS

Considering the published literature in the field, it seems clear that not one of the three FBA systems currently in use meets even the "Foundational validity"⁶⁶ requirement in the P-CAST Report.

Dr Farwell's reported FBA testing results have not, to date, been sufficiently independently replicated despite being applied in differing contexts since the 1990s, while Professor Rosenfeld's Complex Trial Protocol (CTP) FBA system has only been subject to a single attempt at independent replication in 2016 since his CTP FBA protocols were published in 2008.⁶⁷ The Brain Electrical Oscillation Signature (BEOS) FBA system protocols have not been published and subjected to credible peer review in any recognised academic journals at all to date.

In order to reach the P-CAST Report's standard of foundational validity, extensive independent replication of all three FBA protocols will be required, followed by extensive field testing to establish the second level of scientific validity, namely "validity as applied" (i.e. whether the techniques' effectiveness can be used in the real world outside of a scientific setting). The importance of meeting both the foundational validity and the applied validity standards has been emphasised in a recent article by Gerben Meynen.⁶⁸

Meynen refers to all forensic applications related to the brain as "brain-based mind reading" (BMR), and suggests a conceptual framework for BMR which distinguishes between three basic types of BMR, based on how they relate to the subject's knowledge. In addition, he distinguishes three features of BMR techniques: first, whether they require passive cooperation; second, whether they require active cooperation; and third, whether they require that the subject is awake. He points out that each of the types of BMR entails specific risks for forensic psychiatry, involving, for example, confidentiality in the doctor-patient

⁶⁶ That is, the technique is scientifically sound, replicable, and accurate in a laboratory environment.

⁶⁷ See above n 56.

⁶⁸ Gerben Meynen "Brain-based mind reading in forensic psychiatry: exploring possibilities and perils." (2017) 4(2) *Journal of Law and the Biosciences* 311-329.

relationship, and the possibility of coercive use of BMR techniques. He concludes that apart from legal considerations, such as tests of admissibility of evidence, professional ethics is highly relevant.

In particular, Meynen reiterates the warnings of Pardo and Patterson⁶⁹ who argue that brain based lie-detection research may fail to detect what it aims to study: lies. They point to the difficulty of drawing inferences from subjects' lying in a research setting in which lies are actually "permitted" or even encouraged, because they are required for performing the study. In such a context, they argue, it is impossible to *really* lie. If research on brain-based lie detection would face such a fundamental problem, the application of such a technique in a court of law would lack a solid scientific basis. Apart from this research-related issue, ethical and legal qualms have been raised concerning the possible use of BMR against a person's or defendant's will. Furthermore, there are technical concerns. For instance, even if a BMR technique would work in research settings using willing test subjects, actual defendants could take counter measures to hinder or distort mind-reading procedures - which the technique itself may not be able to register - leading to false outcomes.⁷⁰

Therefore, even after satisfying the laboratory-based *foundational validity* requirement (for example, accurately detecting deceit in simulated settings), extensive real-life field studies would be needed to satisfy the *applied validity* requirement (detecting deceit in real-life situations).

It appears probable that the P-CAST Report's foundational and applied validity criteria will have also to be met to ensure the successful admission of FBA evidence (or other novel scientific procedures) in the New Zealand courts. The current legal position in this regard is discussed next.

VIII. EXPERT EVIDENCE ON NOVEL SCIENTIFIC PROCEDURES IN NEW ZEALAND

A key consideration is how novel scientific evidence, including FBA evidence, could be admitted in New Zealand courts in the medium to long term.⁷¹ The experiences to date in other jurisdictions is not encouraging. In India, the Brain Electrical Oscillation Signature (BEOS) system⁷² has been widely used in criminal pre-trial investigations, and reportedly in a number of criminal trials as well. However, as a result of the 2010 *Selvi & Others vs State of Karnataka & Another* decision of the Supreme Court of India,⁷³ BEOS has not been a permissible legal investigative tool in India, nor

⁶⁹ Pardo M., Patterson D. *Minds, Brains, and Law. The Conceptual Foundations of Law and Neuroscience* (Oxford University Press, 2013).

⁷⁰ Above n 68 at 311–314.

⁷¹ Matthew R. Kutcher, Victoria Apold and Jocelyn Downie "Will the Brain Ever Take the Stand? - Canadian Law and the Admissibility of Neurotechnological Lie Detection Evidence Articles and Addresses" (2010) 56 *Criminal Law Quarterly* 135.

⁷² See V above.

⁷³ *Selvi & Others vs State of Karnataka & Another* (5 May 2010) Appeal 1267 of 2004.

admissible in Indian criminal courts. In the *Selvi* case, the Court held that the application of the BEOS system violated a number of fundamental rights in the Indian Constitution, in particular the right against self-incrimination, and could only be used with the suspect's or defendant's express, informed consent. This decision applies to the use of polygraphs and narco-analysis in the Indian criminal justice system as well. It therefore appears that there are a number of significant scientific and legal hurdles that will have to be overcome for the BEOS system to become an accepted forensic procedure in the Indian legal criminal justice system.⁷⁴

In the USA, relying on the application of the so-called *Daubert case* principles,⁷⁵ the Harrington Iowa district court case⁷⁶ remains the only US case in which Dr Farwell's FBA technology has been admitted formally as evidence and considered.⁷⁷

The current position in New Zealand law on admitting expert evidence is governed by s 25(1) of the Evidence Act 2006, which provides that the court may admit expert evidence if it is satisfied that the evidence concerned has the potential to be "substantially helpful" in deciding key issues before the court.⁷⁸ For example, in the 2011 CA case *Shepherd v R*, facial mapping was ruled admissible because it was more reliable and probative than simple eyewitness identification, and therefore potentially 'substantially helpful'.⁷⁹ In this case, the facial mapping evidence was novel scientific evidence that had not previously been admitted in a New Zealand court, but the court emphasised that a cautious approach was required when assessing the admissibility of such evidence.⁸⁰

More recently, in the 2013 Privy Council case of *Lundy v R*,⁸¹ the Court stated that the *Daubert* principles are a good starting point for assessing the s 25 "substantial helpfulness" test, and therefore the admissibility of the evidence concerned.⁸²

In summary, the *Daubert* Principles are that the expert evidence sought to be admitted must:

- (1) Be generally accepted in the scientific community;
- (2) Have been subjected to peer review and publication;
- (3) Have been tested, or be capable of being tested;
- (4) Have acceptable known or potential rate of error; and

⁷⁴ Lyn M Gaudet "Brain Fingerprinting, Scientific Evidence, and 'Daubert': A Cautionary Lesson From India" (2011) 51(3) *Jurimetrics* 293.

⁷⁵ *Daubert v Merrell Dow Pharmaceuticals* 54 APP. D.C., at 47, 293 F.

⁷⁶ *Harrington v State*. Case No. PCCV 073247 (Iowa District Court for Pottawattamie County, 5 March 2001).

⁷⁷ See II.E.2 above.

⁷⁸ See Mahoney, McDonald, Optican and Tinsley *The Evidence Act 2006: Act and Analysis* ((3rd ed , Brookers Ltd, Wellington, 2014) 25.

⁷⁹ *Shepherd v R* [2011] NZCA 666.

⁸⁰ Mahoney and others n 78 at 109.

⁸¹ *Lundy v R* [2013] UKPC 28; [2014] 2 NZLR 273 at [138].

⁸² See Scott Optican "Evidence" (2015) 3 NZ L Rev 473 at 500–502.

(5) Be based on research that was conducted independently of the particular litigation, and not be dependent on an intention to provide the proposed testimony.⁸³

Although the current status of the *Daubert* principles in New Zealand law is that they serve as helpful criteria to assist the court to assess whether a novel scientific technique would be “substantially helpful,” in a case, and therefore admissible as expert evidence, the assessment of *Daubert’s* applicability in New Zealand must take into account recent developments in the USA where *Daubert* has not been followed.⁸⁴

If the underlying science is validated, FBA technology, like the use of polygraphs, is likely to be used as only as an investigative and knowledge- confirmation tool for some time before a suitable court case is found to test the admissibility of FBA technology as expert evidence in a criminal matter.⁸⁵ In this regard, the years of struggle to get DNA evidence admitted as expert evidence in courts in the United States and worldwide, suggests a similar tortuous route for the admission of FBA evidence.⁸⁶

The P-CAST report and the *Daubert* principles, subject to the caveats discussed above, provide clear criteria to guide future FBA research to meet the required threshold of “substantial helpfulness” to satisfy the admissibility criterion for the admissibility of FBA technology in a New Zealand criminal court.⁸⁷

IX. CURRENT PROJECTS ON FORENSIC BRAINWAVE ANALYSIS

Two projects aimed at advancing the process of independently assessing the foundational and applied validity of Farwell’s and Rosenfeld’s FBA systems are currently in place: a 2016 New Zealand Law Foundation supported and University of Canterbury-led pilot project to make a preliminary assessment of Dr Farwell’s FBA system to establish whether there was a sufficient prima facie basis to proceed to extensive laboratory and field testing,⁸⁸ and a series of experiments, commenced in 2015, as part of a PhD study by Michel Funicelli of Concordia University, Montreal, to test the validity of Professor Rosenfeld’s FBA system. An overview of these two projects is given next.

⁸³ Above n 75.

⁸⁴ See E Murphy “Neuroscience and the Criminal/Civil Daubert divide” (2016) 2 FLR 619.

⁸⁵ Francis X. Shen and Owen D. Jones ‘Brain Scans as Evidence: Truths, Proofs, Lies, and Lessons’ (2010) 62 Mercer L. Rev. 861.

⁸⁶ Above n 114, *People v. Castro* 545 N.Y.S.2d 985 (Sup. Ct. 1989), Lander ES “DNA fingerprinting on trial” (1989) 339 Nature 501.

⁸⁷ Lyn M Gaudet “Brain Fingerprinting, Scientific Evidence, and ‘Daubert’: A Cautionary Lesson From India” (2011) 51(3) Jurimetrics 293.

⁸⁸ “Pilot Project: The Brain Does Not Lie: the use of Forensic Brainwave Analysis and Neuroscience in Criminal and Civil Investigations.” New Zealand Law Foundation, Grant 2016/43/6.

A. Funicelli's PhD programme: Assessing the validity of Rosenfeld's Complex Trial Protocol (CTP) FBA system⁸⁹

In 2015, at the Hypnosis and Memory laboratory at Concordia University's psychology department, lead investigator Michel Funicelli (PhD candidate) began a series of EEG based experiments under the supervision of Dr. Jean-Roch Laurence, an expert in the fields of memory and forensic hypnosis. The objective of these experiments was to attempt to validate and extend the understanding of the memory detection protocol developed by Dr. Peter Rosenfeld in 2008 at Northwestern University, better known as the Complex Trial Protocol (CTP)⁹⁰. Funicelli has tested the CTP's performance using a mock theft scenario. A preliminary data analysis points to improved performance when a probe stimulus is deeply encoded into memory, and to the need to test participants in conditions where their attention is maintained with reinforcement through frequent pop quizzes. Further analyses are required before reaching any confirmatory findings.

Funicelli advises that the next round of experiments (2017- 2018) will revolve around a mock terrorism scenario where various types of visual stimuli, such as faces, crime scenes and detailed objects, as well as a memory inhibiting countermeasures are tested.

Contingent on the outcome of the mock terrorism related research, a final inquiry in early 2018 will probe the performance of verbal stimuli to further the understanding of the CTP, including an investigation whether pictorial stimuli are superior to word stimuli.

Funicelli envisages completing these PhD experiments in early 2018, and submitting the results for publication in mid-2018.

B. The NZLF-funded Forensic Brainwave Analysis Pilot Project (2016- 2017)

1. Background

The New Zealand Law foundation funded Forensic Brainwave Analysis Pilot Project ("FBA Project")⁹¹ had its roots in research done for a book on the Law of Evidence (published in 2013), which contains a section on applying new technologies in procedural law.⁹² In the course of this research, contact was made with Dr Lawrence Farwell, the pioneer of brain-fingerprinting (BF), followed by a number of further interactions with him to discuss his possible cooperation in researching brain-

⁸⁹ Michel Funicelli, M.A. (PhD candidate, experimental psychology), Hypnosis and memory laboratory, Concordia University, Montreal, Quebec, Canada. PhD Progress Report, October 2017.

⁹⁰ See IV above.

⁹¹ "Pilot Project: The Brain Does Not Lie: the use of Forensic Brainwave Analysis and Neuroscience in Criminal and Civil Investigations." New Zealand Law Foundation, Grant 2016/43/6.

⁹² Adrian Bellengere and Robin Palmer (eds) *The Law of Evidence: Basic Principles* (Oxford University Press, Cape Town, 2013), 359-364.

fingerprinting.

Although Dr Farwell had been using his unique method of forensic brainwave analysis for over 25 years as at 2013, and there is a substantial body of academic literature on the subject,⁹³ very few verification and replication trials and studies had been done in this time. The main reason for this omission appears to be the perceived need for the commercial protection of his intellectual property over the software and equipment of his version of FBA, in terms of patents registered in 1994 and 1995.⁹⁴

After extensive negotiations in 2014 and 2015 with Dr Farwell, who is based in Seattle, USA, agreement was reached for him to participate in a pilot project as a first step towards possible extended laboratory experiments and field studies, using the University of Canterbury, Christchurch, as a base. The New Zealand Law Foundation (NZLF) agreed to fund the pilot study ("the FBA Project"), which ran from March 2016 to March 2017.

2. Objectives of the FBA Project

The FBA Project was a pilot project to determine the feasibility of engaging in a longer project to attempt to replicate the reported accuracy rates of Dr Farwell's brain-fingerprinting technology; to consider selected aspects of the technology for further scientific investigation, and to isolate pertinent legal, ethical, and cultural concerns arising from its potential use in the legal system. In order to achieve these objectives, the following two specific issues were investigated:

- (1) An assessment of the prima facie reliability and accuracy of FBA technology sufficient to justify the extension of the project to include more extensive laboratory-based experiments and field studies; and
- (2) The identification of, and preliminary investigation into relevant legal, ethical, and cultural factors that would be impacted by the application of this technology in the legal system.

3. The FBA Project Team, Contributors, Researchers and Stakeholders

The FBA project was primarily based at the University of Canterbury (UC) School of Law, with the FBA Project Team co-leaders Professor Robin Palmer and Associate Professor Debra Wilson, and team member Professor Jeremy Finn on the staff there. A key member of the team was Neuroscientist and Neuro-engineer Professor Richard Jones of the New Zealand Brain Research Institute (NZBRI),⁹⁵ The remaining two

⁹³ John Danaher "The Comparative Advantages Of Brain-Based Lie Detection" (2015) 19(1) The International Journal of Evidence & Proof 52.

⁹⁴ Farwell LA *Method and Apparatus for Multifaceted Electroencephalographic Response Analysis (MERA)* US Patent #5,363,858 (1994) Washington DC United States Patent and Trademark Office, Farwell LA *Method and Apparatus for Truth Detection* US Patent #5,406,956 (1995) Washington DC United States Patent and Trademark Office, Farwell LA *Method for Electroencephalographic Information Detection* US Patent #5,467,777 (1995) Washington DC United States Patent and Trademark Office.

⁹⁵ Professor Jones also has concurrent appointments as Senior Biomedical Engineer and Researcher at the Canterbury District Health Board; Research Professor in the Department of Medicine, University of

team members were Associate Professor Colin Gavaghan, Director of the New Zealand Law Foundation (NZLF) Centre for Law and Policy in Emerging Technologies at the University of Otago, and Professor Chris Gallavin of Massey University.

The FBA Project team was expanded during the course of the year to include a number of ad hoc contributors, namely Dr Jeanne Snelling (University of Otago), Professor Kris Gledhill (Auckland University of Technology), Mr Simon Dorset (UC School of Law), Dr Ewald Neumann (University of Canterbury, Department of Psychology), and Dr Abby Suszko (Office of Assistant Vice-Chancellor Māori, University of Canterbury). Seven student research assistants from the Schools of Law and Psychology were also recruited to assist with the project.

Finally, whilst it was recognised that all role-players in the New Zealand justice system are obvious potential stakeholders in the FBA research project, for the purposes of the pilot project the stakeholder involvement was limited to the New Zealand Police⁹⁶ and the Department of Corrections⁹⁷. Should the project be extended, other relevant stakeholders, such as the Departments of Health, Social Welfare and Te Puni Kōkiri (Ministry of Māori Development); as well as law societies, bar associations and the judiciary, will also be engaged.

4. The FBA Project Conclusions

After completing the pilot phase, the FBA Project Team was satisfied that the science on which forensic brainwave analysis (FBA) technology is based provided sufficient confidence for further experiments and testing, with necessary independent replications, to attempt to confirm the accuracy and reliability of FBA to reach the P-CAST Report standard for foundational validity. If this standard can be met, further laboratory and field-testing will be done to attempt to achieve the P-CAST standard of validity as applied.

In addition, it was concluded that the baseline research done on police investigation procedures, legal ethics and rights, evidential issues and bi-and multi-cultural impacts provided a solid foundation for further doctrinal and empirical research in these areas.

The specific areas that are being considered for further research are:

- *Independent replications of Farwell's FBA testing protocols:* This would entail independent replication of Dr Farwell's FBA test protocols in laboratory and field-study settings, and comparing the results to those reported by Farwell. In this regard, the New Zealand Police and Corrections Department could be field-study partners, focusing on suspect and informer identification, and the testing of sentenced prisoners who refuse parole opportunities due to the consistent assertions of their innocence.

Otago; Professor in the Department of Electrical and Computer Engineering, University of Canterbury; Professor in the Department of Psychology, University of Canterbury, and Director of the Christchurch Neurotechnology Research Programme.

⁹⁶ Represented by Superintendent John Price, District Commander for the New Zealand Police Force of the Canterbury Region, and Detective Superintendent Peter Read, South Island and Wellington.

⁹⁷ Represented by Southern Regional Commissioner, Ben Clark.

- *Comparing the results of the Farwell protocol FBA replication testing to similar tests by other researchers using the Rosenfeld protocols:* Contact has been made, and tentative collaboration parameters discussed, with Michel Funicelli, who is currently doing replication studies using Rosenfeld's FBA protocols. A series of collaborative and comparative FBA experiments could be done, using exactly the same test-subject demographic and scenarios in New Zealand using Farwell's protocols, and Canadian researchers using Rosenfeld's protocols. This project could also be extended to comparisons with the BEOS system in the future.⁹⁸
- *Post-validation advanced FBA experiments:* Should the basic reliability and accuracy of FBA be established to at least foundational validity standard, further focused experiments on various identified factors that may affect the basic reliability and accuracy of FBA could be considered. These factors are:
 - Effects on the accuracy of FBA testing due to the influence of neurological and psychiatric disorders on memory formation and recall;
 - Effects on the accuracy of FBA testing due to the influence of recreational drugs or alcohol on memory formation;
 - Effects on the accuracy of FBA testing due to time transpired on primary concealed memories and secondary incidental memories;
 - Effects on the accuracy of FBA testing by 'fuzziness' in probe-stimuli, such as due to poor lighting or very brief exposure;
 - Effects on the accuracy of FBA testing by assessing the effect of false implanted memories (whether negligent or intentional);
 - Effects on the accuracy of FBA testing by the ability to consciously suppress ERP (P300 brainwave) responses to probes; and
 - Strategies and protocols for substantially reducing the time needed for the FBA testing process without sacrificing accuracy and reliability.
 - In the longer term, comparative studies with other concealed information detection systems, such as polygraphs and fMRI, would be appropriate. This is especially important as the main advantage of FBA over polygraphs and fMRI is the fact that unlike these two FBA does not claim to detect deceit- it merely detects the presence or absence of certain crucial knowledge (probes). The inference of deceit may, or may not be justified, depending on the circumstances. The crucial aspects to be compared would accuracy and reliability, and susceptibility to countermeasures.
- *Further legal, ethical and cultural research in the context of FBA:* Building on the foundational research done in these areas for the FBA project, and subject to the foundational validity of the FBA testing process being established, further advanced research on legal, ethical and cultural issues relevant to FBA could be done with emphases on the following:
 - *Legal issues:* The right against self-incrimination; Investigation procedures to identify and prevent the contamination of *probes*; Whether suspects can be compelled to undergo FBA testing; The impact of expert evidence rules; The application of legal defences like insanity; Specific rules for children and vulnerable people; Establishing the evidentiary rules for admitting expert evidence on new technologies in New Zealand law, and the use of search warrants to "search" the contents of the brain.
 - *Ethical and Rights issues:* Assessing scope and ambit of current rights and protections in the context of neurological CIT procedures in general, and FBA in particular; Access to justice issues (in the sense of equitable access to the use of FBA technology); The potential for false confessions; Investigational ethics and safeguards, in particular the potential for memory to be deliberately or inadvertently influenced during the investigation; dealing with vulnerable test subjects (mental deficiency; youth, etc); and ensuring the honesty and competence of FBA testers.
 - *Cultural issues:* Identifying appropriate FBA implementation practices for Māori, Pasifika and other New Zealand minority cultural groups, including aspects such as researching the effect of the sanctity of the head area in Māori and other cultures

⁹⁸ See V above.

(especially whether reliance on this cultural belief could establish a legal right to refuse to be FBA tested); Dealing with the perception of police bias against certain communities; and understanding different facets of bi- and multi-cultural etiquette and practices in the context of FBA testing.

Research into the legal, ethical and cultural impacts of FBA testing is a crucial corollary to the attempted scientific validation of the science underpinning forensic brainwave analysis. This is because legal challenges to the admissibility in court of FBA evidence will not be confined to attacks on FBA's scientific reliability and accuracy: admissibility challenges based on alleged rights violations flowing from the use of FBA technology at both investigation and trial stages are just as likely.⁹⁹

X. OVERALL CONCLUSIONS

Forensic brainwave analysis technology appears to have the potential to make a significant contribution to the administration of justice, in both civil and criminal settings. The primary potential application would be in the area of criminal justice, including anti-terrorism initiatives, but the potential for other applications, such as in civil disputes, employment disputes, and in schools and other non-legal settings is promising as well. However, the foundational and applied validity of FBA technology will first have to be unambiguously established, with all relevant legal rights, ethics and cultural safeguards and protections put in place.

On a cautionary note, however, even if the foundational and applied validity of FBA technology were to be successfully established, the history of the slow and incremental process of entrenching forensic DNA analysis technology as an integral part of legal systems around the world suggests that getting a similar level of acceptance for forensic brainwave analysis technology could still take much time and effort. In this regard, the approach of the courts to the reliability and admissibility of FBA evidence will be pivotal.

⁹⁹ See *Selvi & Others vs State of Karnataka & Another* (5 May 2010) Appeal 1267 of 2004, and VIII above.

Annexure A Acronyms and Abbreviations

- BEAP: Brain Electrical Activation Profile.
- BEOS: Brain electrical oscillation system.
- BF: Brain fingerprinting.
- BMR: Brain-based mindreading.
- CIT: Concealed Information Test.
- CQT: Control Question Test.
- CTP: Complex trial protocol.
- EEG: Electroencephalogram, or the process of using it, electroencephalography.
- EK: Experiential Knowledge (BEOS System).
- ERP: Event-related Potential.
- FBA: Forensic Brainwave Analysis.
- FBA Project: New Zealand Law Foundation, Grant 2016/43/6 - Pilot Project.
- fMRI: Functional magnetic resonance imaging.
- GAO: US Government Accountability Office.
- GAO Report: The US Government Accountability Office Brain-fingerprinting Report (2001).
- GKT: Guilty knowledge test.
- MERMER: Memory and Encoding Related Multifaceted Electroencephalographic Response.
- P-CAST: Report to the US President: Forensic Science in Criminal Courts: Ensuring scientific validity of feature-comparison methods" (September 2016).