# USING fMRI AS A LIE DETECTOR – ARE WE LYING TO OURSELVES?

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## I. INTRODUCTION

At this moment, the technology exists to read your mind. If you are like most people, this may come as a shocking concept, but it is a true statement, in a manner of speaking. Specifically, several companies and academics are researching technologies that will read the activity of your brain and attempt to correlate this with deception. While the potential benefits of this technology are obvious to the legal profession, it also raises several thorny ethical and moral questions. Among these are: what are the privacy implications of such a technology, and does the social benefit that might result from the use of this technology justify what could arguably be the most intimate invasion of personal integrity possible? While wrestling with these and other issues, one must note that the technologies being developed as lie detectors are not one hundred percent accurate. The question becomes: how should the data from these tests be used in light of the fact that they are not one hundred percent accurate? These technologies all assume that brain activity correlates with actual thought, but our current knowledge is insufficient to know this for certain. As a result, brain imaging technologies must be critically examined before they become an accepted means of determining truth from lie.

The primary focus of this note is how functional magnetic resonance image (fMRI) technology is much more limited as a lie detector than it may at first seem and how, as it is being developed today, it is unlikely to produce valid data for very significant portions of the population. This note will explore the limitations of fMRI technology as a lie detector technology and analyze the development of this tool with an eye towards better tailoring its use to fit the needs of society, the legal profession, and justice itself.

## II. LIE DETECTION HISTORY

Humanity has long been fascinated by the idea of detecting lies.[1] Early attempts to detect lies included the "Ordeal of Boiling Water," in which a person had to stick his or her hand in a pot of boiling water and was believed to be telling the truth if the hand was not burned, and the "Ordeal of the Red-Hot

[1] Sarah E. Stoller & Paul Root Wolpe, *Emerging Neurotechnologies for Lie Detection and the Fifth Amendment*, 33 AM. J.L. & MED. 359, 359 (2007).

Stones," where the person would be judged truthful if he or she could walk across red hot stones and not have his or her feet burned.[2] Obviously these tests did not prove successful, and humanity's quest continued.

### *a. Polygraph*

The polygraph machine was one of the first serious attempts at using a scientific method for detecting lies.[3] The polygraph relies on indirect measurements associated with anxiety including blood pressure, pulse rate, respiration, and electro-dermal responses.[4] Blood pressure and heart rate are measured through use of the standard "cuff" most people are familiar with, respiration is measured through the use of rubber hoses fastened around the chest and waist of the subject, and the electro-dermal responses are measured by using metal contacts, typically attached to the subject's fingers.[5]

### *b. Problems with the Polygraph*

The polygraph has had a checkered history in the American judicial system.[6] The device, an intimidating amalgamation of wires, hoses, and even chains, came into being in the "Roaring '20s" when the country was in the grasp of Prohibition and law enforcement needed a way to separate truth from lies.[7] At the time, the technology used the best measures then-modern science could apply. In retrospect, the machine is seriously flawed and several questionable assumptions must be made in order to find it even arguably reliable.

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[2] Aachen Polygraph Associates, The History and Basic Facts of Polygraph, http://www.polygraphexaminer.com/polygraph-history.html (last visited Jan. 25, 2009).

[3] *See id.*

[4] Leo Kittay, *Admissibility of fMRI Lie Detection: The Cultural Bias Against "Mind Reading" Devices*, 72 BROOK. L. REV. 1351, 1361–62 (2007).

[5] *Id.* at 1362. The theory behind the "galvanic skin response" is that the skin's resistance to electricity changes if a subject sweats since the water released lowers the skin's natural resistance to an electric signal. Cops, Inc., *supra* note 2; Robert Todd Carroll, The Skeptics Dictionary, Plant Perception (a.k.a. the Backster Effect), http://skepdic.com/plants.html (last visited Feb. 1, 2009).

[6] Sean Kevin Thompson, *A Brave New World of Interrogation Jurisprudence?*, 33 AM. J.L. & MED. 341, 341–42 (2007).

[7] Dina Temple-Raston, *Foolproof Test for Catching Liars Still Elusive* (NATIONAL PUBLIC RADIO Oct. 29, 2007), *available at* http://www.npr.org/templates/story/story.php?storyId=15670581.

The responses measured by a polygraph have been correlated with lying, but the connection is tenuous at best.[8] In fact, evidence has repeatedly been presented showing that increased heart rate, blood pressure, and respiration are not "uniquely related to deception"[9] and may predict truth telling "little better than 'the toss of a coin.'"[10] Further, there is significant evidence that the manner and perceptions of the examiner can have a dramatic effect on the outcome of the test.[11] A famous example is that when examiners test highly placed members of government organizations, there are virtually no failures; however, when applicants for entry-level positions are tested, as many as forty percent fail.[12] Courts have been understandably reluctant to allow a test to be used in situations where someone's very liberty is at stake, when the technology has not been shown to be both reliable and valid.[13]

### *III. Lie Detection Today*

In light of the deficiencies inherent in polygraph testing, several other technologies are currently being tested as potential alternatives. Among these are: brain fingerprinting, positron emission tomography, and functional magnetic resonance imaging.

#### *a. Brain Fingerprinting*

The theory behind brain fingerprinting is that by measuring the electrochemical emissions of the brain in response to a particular stimulus such as a picture or a written word, one can theoretically determine if the perceived stimulus is recognized by the subject.[14] The output of a brain fingerprinting test is

[8] Kittay, *supra* note 4, at 1363 (quoting NAT'L RES. COUNCIL, BD. ON BEHAVIORAL, COGNITIVE, & SENSORY SCIENCES & COMM. ON NAT'L STATISTICS, NAT'L RES. COUNCIL, THE POLYGRAPH AND LIE DETECTION 212 (2003), *available at* http://www.nap.edu/openbook.php?record_id=10420&page=212).

[9] NAT'L RESEARCH COUNCIL, *supra* note 8, at 212.

[10] United States v. Cordoba, 991 F. Supp. 1199, 1203 (C.D. Cal. 1998) (citing references omitted).

[11] Kittay, *supra* note 4, at 1362.

[12] Temple-Raston, *supra* note 7.

[13] Autoforge, Inc. v. American Axle & Mfg, Inc., 75 Fed. R. Evid. Serv. 466, 466 (W.D. Pa. 2008); Cordoba, 991 F. Supp at 1201–02; Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 589 (1993).

[14] *See* Jody C. Barillare, *As Its Next Witness, The State Calls . . . The Defendant: Brain Fingerprinting As "Testimonial" Under the Fifth Amendment*, 79 TEMP. L. REV. 971, 976 (2006) (showing the various stimuli presented to the

called a memory and encoding related multifaceted electroencephalographic response, or "MERMER," and is detected via a strap placed around the head connected to an electroencephalograph.[15] A MERMER is composed of several signals, including a recording of what is referred to as a "P300 wave."[16] The P300 wave is actually a composite of hundreds or thousands of neuronal firings taking place between 300 and 800 milliseconds after a person is exposed to stimuli that is significant to him or her.[17] MERMERs are thought to occur in a person's brain whenever he or she is confronted with a familiar stimulus.[18] The theory behind using MERMERs for lie detection is that when criminals are confronted with pictures of scenes of their crime or their victim's name, a MERMER will "give them away," while an innocent person confronted with the same images will not generate a MERMER.[19]

Brain fingerprinting has several problems, however. First, though the test may be able to determine if a person has particular knowledge, the test cannot say why they have it.[20] Thus, a person who read about a crime, or spoke to someone who did, could generate a MERMER to certain images that authorities could then associate with the perpetrator. Second, this test is dependent upon examiner skill and bias, just like the polygraph test.[21] The reason is that the examiner will have to determine the subject's baseline MERMER through a series of preliminary "questions," and if this is not done carefully, the subject could inadvertently be exposed to sensitive information that could later generate a MERMER when guilt-implicating stimuli are presented.[22] The difficulty in designing a valid series of preliminary questions is greatly increased when one considers the myriad number of potential factual situations and crimes to be analyzed, as well as the short time frame in which this

subject, and discussing the theory of how the brain will respond differently to different categories of stimuli).

[15] *Id.* at 975–76; Archie Alexander, *Functional Magnetic Resonance Imaging Lie Detection: Is a "Brainstorm" Heading Toward the "Gatekeeper"?*, 7 HOUS. J. HEALTH L. & POL'Y 1, 36 (2006).

[16] Alexander, *supra* note 15, at 36.

[17] *Id.*

[18] Barillare, *supra* note 14, at 975–76.

[19] *Id.* at 975–77.

[20] *Id.* at 977.

[21] *See id.* at 977–78 (discussing how an examiner's actions may affect the outcome of the testing).

[22] *Id.*

information will likely be demanded. Finally, brain fingerprinting has not been thoroughly studied by the scientific community and so would likely fail to meet the *Daubert* test of admissibility for use in a criminal trial.[23]

*b. Functional Brain Imaging*

Unlike the polygraph and brain fingerprinting tests, brain imaging does not involve correlating aggregate signals detected outside of the body with deception.[24] Rather, these technologies attempt to detect deception by examining specific molecular events occurring within the brain itself.[25] Two of the most studied methods of brain imaging in a deception detection context are positron emission tomography (PET) and functional magnetic resonance imaging (fMRI).[26]

i. Positron Emission Tomography (PET) Scan

Positron emission tomography (PET) creates images of the brain using one or more tracer materials[27] and detecting the emissions from these materials through use of an external scanner. Positron emission tomography is used to determine levels of metabolic action in specific tissues using radioactive metabolites (the most common is [18F] 2-Fluoro-2-Deoxy-D-Glucose, which substitutes for normal glucose). Use of PET is advantageous because of its high sensitivity and the large range of potential tracer materials.[28] However, PET also has inherent drawbacks. The major drawback is that the tracer materials are radioactive.[29] While providing excellent signal quality and good

[23] *See infra* Part IV(b).

[24] *See* Alexander, *supra* note 15, at 15–17 (explaining how the signals measured are generated in the brain–an internal process).

[25] *See generally id.* at 15–24.

[26] Laurence R. Tancredi & Jonathan D. Brodie, *The Brain and Behavior: Limitations in the Legal Use of Functional Magnetic Resonance Imaging*, 33 AM. J.L. & MED. 271, 272–73 (2007).

[27] Tracers are radioactively-labeled probes that circulate through the blood, penetrate the blood-brain barrier and attach to particles of interest. In the deception detection context the molecule of choice is typically glucose, because increased activity of specific brain regions requires higher levels of glucose consumption than non-active or minimally active regions. *Id.* at 273–74. *See generally* Eric R. Kandel et al., PRINCIPLES OF NEURAL SCIENCE, 376–77 (John Butler & Harriet Lebowitz eds., McGraw-Hill Health Professions Division 4th ed. 2000) (1991).

[28] Tancredi & Brodie, *supra* note 26, at 274.

[29] *Id.* at 272 n. 6.

resolution, the tracer materials release radioactive energy in the brain and this necessarily limits the number of times a particular subject can be safely analyzed and how close together in time two or more tests can be run on any one individual.[30] Also, because PET requires the addition of an exogenous material, there can be problems with distribution of the tracer throughout the brain as well as degradation of the tracer (and thus the signal) over time.[31]

ii. Functional Magnetic Resonance Imaging (fMRI) Scans

Functional magnetic resonance technology creates images of the brain by detecting changes in the amount of oxygen bound to hemoglobin throughout each vein or artery in the brain over time.[32] Blood has significantly different magnetic properties when oxygenated blood is present versus when non-oxygenated blood is present.[33] During an fMRI scan, powerful magnets are used to "bounce" the oxygen in the blood and the signals emitted will differ depending upon the oxygenation state of the blood in a particular region of the brain at that time.[34] The theory underlying this technology is that when specific brain regions are active they consume significantly greater amounts of oxygen than regions of the brain that are not active at that moment.[35] Analysis of fMRI data consists of three discrete steps. First, the data generated must be pre-processed in order to reduce noise and prepare the data to be properly analyzed by more rigorous statistical methods.[36] Second, the data is subjected to a linear regression model in which the data from each brain region is refined to determine the changes in activity in that region during the test.[37] Third, the data is subjected to a "population

[30] *Id.* at 276–77.

[31] *See* Kandel et al., *supra* note 27, at 374–75 (for example, oxygen is a common radiotracer and is only active for two minutes).

[32] Alexander, *supra* note 15, at 18–19, 21–22; *see also* Kandel et al., *supra* note 27, at 370, 374.

[33] Alexander, *supra* note 15, at 21; Kandel et al., *supra* note 27, at 370.

[34] Alexander, *supra* note 15, at 21; Kandel et al., *supra* note 27, at 370.

[35] Kandel et al., *supra* note 27, at 374–75; Tancredi & Brodie, *supra* note 26, at 275.

[36] Stuart Clare, Functional MRI: Methods and Applications, Ch. 6, Part 6.1 (Oct. 1997) (unpublished Ph.D. dissertation, University of Nottingham), *available at* http://users.fmrib.ox.ac.uk/~stuart/thesis/fmri.pdf.

[37] Henry T. Greely & Judy Illes, *Neuroscience-Based Lie Detection: The Urgent Need for Regulation*, 33 AM. J.L. & MED. 377, 383 (2007).

inference."[38] The population inference compares the changes in activity in specific brain regions to the results of others in similar experimental paradigms.[39] This allows an accurate determination of how the observed changes in brain activity correlate to the behavioral task administered during the fMRI test by applying large scale population statistics to the data.[40] In other words, because each person's brain is slightly different, a composite signal comprised of an average of many responses will provide better statistical confidence that a particular individual's results are or are not abnormal. It is this third step that allows for the unprecedented accuracy in lie detection as well as to the problems that will be discussed later in this note. In some ways, fMRI is very similar to PET technology. First, both technologies are capable of creating images of the brain in real time and do so through the use of an internally generated signal.[41] Second, both PET and fMRI measure very specific metabolites of neural activity, though in fMRI the metabolite is oxygen bound to hemoglobin and in PET it is glucose.[42] However, fMRI has important advantages over PET that make it the best currently available technology for deception detection. The primary advantage is that fMRI does not require the use of any tracer materials.[43] Instead, fMRI measures the inherent response of hemoglobin in a strong magnetic field and, as such, avoids the aforementioned problems with PET (i.e. toxicity and imperfect signal distribution).[44] As a result, fMRI can be used without limitation on the same subjects without fear of radiation poisoning.[45] Further, with the introduction of newer and more powerful magnets in recent years, the resolution of fMRI is now on par with that of PET.[46] Because of its superior safety profile and comparable specificity and resolution, fMRI has been one of the most studied technologies for use in the detection of deception.[47] Partially as a result of this large amount of study,[48]

[38] *Id.*
[39] *Id.*
[40] *Id.*
[41] Tancredi & Brodie, *supra* note 26, at 275–76.
[42] *Id.* at 273–75; Kandel et al., *supra* note 27, at 374–75.
[43] Tancredi & Brodie, *supra* note 26, at 276–77; Jennifer Kulynych, *Psychiatric Neuroimaging Evidence: A High-Tech Crystal Ball?*, 49 STAN. L. REV. 1249, 1255–56 (1997).
[44] Tancredi & Brodie, *supra* note 26, at 277–78.
[45] *Id.* at 277.
[46] *Id.* at 278.
[47] *See, e.g., id.* at 280–82 (discussing the various studies that fMRI

companies are forming and pursuing the refinement of the technology to the point where it can be used in a courtroom setting.[49]

Caution should be exercised in the adoption of fMRI technology, however. One reason for caution is that there is an underlying assumption by those using brain imaging technologies that structure equals function.[50] While practically assumed in the scientific community, there is no definitive proof that activity in a particular brain region translates directly to particular behavior, such as lying.[51] Another reason for caution is that even though oxygen consumption by neurons is strongly correlated with activity of those cells, it is still an "indirect measure," and as such, can be affected by changes occurring elsewhere in the body or the introduction of drugs into the body.[52] Additionally, studies have only recently begun focusing on the reproducibility of fMRI results across facilities or even within a single individual in a single facility.[53] As a result, the true reliability of the technology as a deception detector will not be known for some time.[54] Finally, the studies performed with fMRI

technology is and has been undergoing).

[48] This attribute makes the technology more attractive to commercial enterprise because, under the *Daubert* analysis, well-studied technologies are more likely to pass the test and produce admissible evidence. *See infra* Part IV(b) for a discussion of the *Daubert* analysis.

[49] Such companies include Cephos Corp. and No Lie MRI. Cephos Corp., http://www.cephoscorp.com (last visited Feb. 2, 2009); No Lie MRI, http://www.noliemri.com (last visited Feb. 2, 2009).

[50] *See*, *e.g.*, F. Andrew Kozel et al., *A Pilot Study of Functional Magnetic Resonance Imaging Brain Correlates of Deception in Healthy Young Men*, 16 J. NEUROPSYCHIATRY & CLINICAL NEUROSCIENCES 295, 301–04 (2004) (showing the various problems in the structure of the test performed and the need for additional testing prior to implementation to perfect the data collection techniques and provide for more real life application scenarios).

[51] *See, e.g., id.* at 301–02 (stating that they hypothesized that there would be increased activity during deception as opposed to truth-telling, however, the actual study showed that "fMRI within individuals as presently applied [was] neither sensitive nor specific for detecting deception").

[52] Tancredi & Brodie, *supra* note 26, at 280.

[53] *See* Stephen M. Smith et al., *Variability in fMRI: A Re-Examination of Inter-Session Differences*, 24 HUM. BRAIN MAPPING 248, 248–49, 257 (2005) (analyzing variances within sessions and discussing ways to overcome these differences); *see also* Oleg Leontiev & Richard B. Buxton, *Reproducibility of BOLD, Perfusion, and CMRO$_2$ Measurement with Calibrated-BOLD fMRI*, 35 NEUROIMAGE 175, 175–76, 183 (2007) (examining reproducibility and reducing variance in fMRI testing); Frank Andrew Kozel et al., *A Replication Study of the Neural Correlates of Deception*, 118 BEHAV. NEUROSCIENCE 852, 852, 854-55 (2004) (seeking to achieve more consistent results).

[54] The lack of this crucial information is also likely to cause problems for

technology to date have dealt with cooperative individuals, none of whom were in danger of going to jail for long periods of time.[55] It remains to be seen how the presence of an uncooperative or even hostile individual might affect the outcome of fMRI studies in a particular individual.[56]

Though fMRI is not currently a perfect technology, it remains the best hope for becoming what the polygraph never could: a reliable lie-detecting device to help the trier of fact resolve disputes in civil or criminal settings. With the significant amount of research being performed today on the technology and the multiple corporate entities funding its development for use in the American courts, it seems likely that judges will eventually have to decide whether or not to admit the data generated by fMRI.

*c. Controversies Regarding Lie Detection Technologies*

A controversy that began with the polygraph and continues today is the problem of respecting privacy concerns while using lie-detection technologies. Specifically, there is concern regarding the potential use of this information by employers or insurers to exclude people from obtaining employment or insurance.[57] These concerns stem from the inaccuracy of the technologies and the potential for misuse by employers or insurers.[58] An example of this misuse would be a potential employer using carefully worded questions to force the potential employee to disclose sexual preference (or lie), a topic normally disallowed in determining whether to employ someone. In the

proponents of the technology with respect to meeting the *Daubert* test. *See infra* Part IV(b) (showing the lack of scientific agreement as to the reliability of fMRI testing and how that could hinder its admissibility under the *Daubert* test).

[55] *See, e.g.,* F. Andrew Kozel et al., *Detecting Deception Using Functional Magnetic Resonance Imaging*, 58 BIOLOGICAL PSYCHIATRY 605, 610, 612 (2005); Sean A. Spence et al., *A Cognitive Neurobiological Account of Deception: Evidence From Functional Neuroimaging*, 359 PHIL. TRANSACTIONS ROYAL SOC'Y 1755, 1760 (2004).

[56] fMRI studies are very sensitive to the movement of the individual being tested and so the hurdles in obtaining reliable results from a hostile subject are significant. *See* Alexander, *supra* note 15, at 22.

[57] Stacey A. Tovino, *The Confidentiality and Privacy Implications of Functional Magnetic Resonance Imaging*, 33 J.L. MED. & ETHICS 844, 847 (2005).

[58] 134 CONG. REC. S7502-02 (daily ed. June 9, 1988) (statement of Sen. Kennedy).

case of functional brain imaging technologies, there is additional concern that the images captured by the tests can point out physical issues such as brain tumors and developmental abnormalities in addition to determining honesty.[59] If such data is generated as a by-product of a lie-detection test, particularly during a judicial proceeding, what will stop employers and insurers from accessing this information when making employment or coverage decisions?

In response to concerns over the use of polygraph testing in the workplace as a condition for hire, the United States enacted the "Employee Polygraph Protection Act" (EPPA),[60] which prohibits employers from forcing potential employees to undergo a polygraph test "or any other similar device . . . that is used, or the results of which are used, for the purpose of rendering a diagnostic opinion regarding the honesty or dishonesty of an individual."[61] Whether or not the EPPA will apply to the use of functional brain imaging technologies has yet to be determined, but some legislation will be required to regulate the use of information generated as a result of functional brain imaging tests otherwise abuses such as those outlined above could become prevalent.

An additional question raised by lie detection technologies is whether or not their use violates the Fifth Amendment prohibition on self-incrimination in criminal cases. In *Miranda v. Arizona*, the Supreme Court said "to respect the inviolability of the human personality, our accusatory system of criminal justice demands that the government seeking to punish an individual produce the evidence against him by its own independent labors, rather than by the cruel, simple expedient of compelling it from his own mouth."[62] One week later, the Supreme Court placed a limitation on Fifth Amendment protection, saying "the privilege is a bar against compelling 'communications' or 'testimony,' but that compulsion which makes a suspect or accused the source of

[59] *See* Tovino, *supra* note 57, at 847 (discussing concerns as to how to keep certain information regarding physical abnormalities private while still allowing some honesty information to be distributed).

[60] *See* 29 U.S.C. § 2002(1), (3) (2000) (barring employers from requiring or even suggesting that an "employee or prospective employee . . . take or submit to any lie detector test," and barring any disciplinary action towards an employee or perspective employee "who refuses" a test).

[61] 29 U.S.C. § 2001(3) (2001).

[62] Miranda v. Arizona, 384 U.S. 436, 460 (1966) (citing Chambers v. Florida, 309 U.S. 227, 235–38 (1940)).

'real or physical evidence' does not violate it."[63] An example of unprotected "real or physical evidence" would be blood, or DNA. As lie detection technology advances, humanity is able to look deeper into the human body for clues regarding disease, development, and behavior. In terms of the Fifth Amendment privilege against self-incrimination, the question becomes: when does an examination of the human body become equivalent to a "communication" or "testimony" rather than "real or physical evidence."

While these are issues of great importance, a predicate issue, and the focus of the rest of the paper, is whether, even before privacy and Fifth Amendment protections are threatened, fMRI is reliable enough to be admitted into evidence in a judicial proceeding. Until it is, the questions raised above are merely theoretical exercises. Given the mechanism underlying fMRI technology and problems with data interpretation and validation of study design,[64] it is unlikely fMRI technology will become accepted for widespread use in the American judicial system at any time in the near future.

## IV. EVIDENCE PROBLEM

In order to be accepted as evidence in a judicial proceeding, fMRI will need to jump over several hurdles including Federal Rule of Evidence (FRE) 403, and FRE 702, and the test the U.S. Supreme Court introduced in *Daubert v. Merrill Dow Pharmaceuticals*.[65] The Daubert analysis will be the most important hurdle for fMRI technology, and is discussed in detail below.

### *a. Federal Rule of Evidence 403*

Federal Rule of Evidence 403 provides that "relevant evidence may be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury, or by considerations of undue delay, waste of time, or needless presentation of cumulative evidence."[66] The application of this rule to lie-detecting technology is not new. In some cases, even when data might

[63] Schmerber v. California, 384 U.S. 757, 764 (1966).
[64] *See supra* Part III(b)(ii).
[65] Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 593–95 (1993).
[66] FED. R. EVID. 403.

otherwise pass a *Daubert* analysis, courts have excluded it due to a concern that the jury would overvalue it.[67] With brain imaging technologies, worry over prejudice may be warranted, due to the powerful images produced by the test.[68] As a result, if fMRI evidence is ever admitted, proper jury instructions must be developed to prevent the jury from overvaluing or misapplying the evidence produced. Even with proper jury instructions, courts should exclude fMRI evidence if the judge determines prejudice will result for any of a number of reasons, as has been done with polygraph evidence.[69]

*b. Federal Rule of Evidence 702 (Daubert Analysis)*

Rule 702 allows someone who qualifies as an expert to testify as to "scientific, technical, or other specialized knowledge [if it] will assist the trier of fact to understand the evidence or to determine a fact in issue[.]"[70] Given the complex nature of brain imaging technology, it is likely such testimony will be required for the admission of fMRI results. Further, it is likely that the test put forth by the U.S. Supreme Court in *Daubert* and added to FRE 702 will be the major obstacle to admitting fMRI results into evidence. The *Daubert*-motivated addition to FRE 702 requires an evaluation of three things before any technical or scientific evidence can be admitted through expert testimony: "(1) the testimony [must be] based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case."[71] Courts will also consider the

[67] *See, e.g.,* United States v. Scheffer, 523 U.S. 303, 313–14 (1998) (discussing an exclusion of polygraph evidence due to concern over a jury giving undue weight to the evidence); United States v. Apperson, 441 F.3d 1162, 1196 (10th Cir. 2006) (excluding the results of two polygraph tests due to potential overvaluing by the jury).

[68] *See* Joseph H. Baskin et al., *Is a Picture Worth a Thousand Words? Neuroimaging in the Courtroom*, 33 AM. J.L. & MED. 239, 268 (2007) (stating that due to the "dazzling multimedia displays" a juror may find fMRI evidence "irresistible" and therefore possibly "inflate the scientific credibility of the information presented"); Tancredi & Brodie, *supra* note 26, at 287 (noting that fMRI tests have "strong persuasive power" that can be "viewed as a 'visual truth' and thereby perceived as factually correct"); *see also* Google Images Search, http://images.google.com (search for "fMRI Images") (last visited Feb. 2, 2009).

[69] *See, e.g.*, Scheffer, 523 U.S. at 313–14; Apperson, 441 F.3d at 1196.

[70] FED. R. EVID. 702.

[71] *Id.*

factors outlined in the *Daubert* opinion itself, to wit: (1) the falsifiability, or refutability, or testability of the expert's reasoning or methodology, (2) peer review and publication of the expert's theory or technique, (3) the known or potential rate of error of the particular scientific technique, (4) the existence and maintenance of standards controlling the technique's operation, and (5) whether the technique is generally accepted in the relevant scientific community.[72]

One of the major hurdles for fMRI at this point in time is the lack of "sufficient facts or data." Though several studies have been completed, and many more are ongoing, there is not yet a consensus in the scientific community as to the technology's reliability, or even validity.[73] These questions exist at both the between subjects level[74] (different people being tested) and the within subjects level[75] (where the same person is tested repeatedly).

Another hurdle for fMRI testing is that judges must agree that the testimony regarding fMRI use is "the product of reliable principles and methods." The first *Daubert* factor of "sufficient facts or data" is intimately associated with this factor in the case of fMRI. This is because the principles and methods of analysis of fMRI data is, and will be, based upon the data generated by the exploratory and validation studies carried out by both corporate and academic entities. Both of these types of entities are constrained by the availability of test subjects and financial barriers to constructing appropriate testing pools. As a result, any issues regarding study, design, or the populations used in these studies could lead to a determination that the evidence is not based on reliable principles or methods even if there is a significant body of study and large amounts of data available, depending upon how the studies are constructed.[76]

The third *Daubert* factor, "proper application of the principles to facts of the case," is likely to be the least problematic for admitting fMRI evidence in the courtroom. Once the issues involved in meeting the other two Daubert factors have been

[72] Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 593–95 (1993).

[73] *See* Tancredi & Brodie, *supra* note 26, at 280–86 (showing various studies currently being conducted and the results they have encountered establishing a lack of uniformity within the fMRI field).

[74] *Id.* at 281.

[75] Smith, *supra* note 53, at 248.

[76] *See supra* Part III(b)(ii).

solved, it will then be an individual expert's job to properly apply what the scientific community has learned. In principle, this is no different than for any other type of scientific or technical evidence an expert must deal with.

Though the accumulating data will make for a stronger case for admission of fMRI results, previous judicial experience with polygraph testing will likely result in significant judicial resistance to admission of these results, at least initially. Indeed, the fact that no fMRI test has ever been admitted in a trial for the purpose of establishing truthfulness[77] is strong evidence of this point. Regardless of judicial hesitancy, courts are already facing the issue of admitting this evidence. Illinois is one state that has already wrestled with this issue, in *Entertainment Software Association v. Blagojevich*.[78] In that case, Illinois tried to introduce expert testimony based on fMRI results to defend the constitutionality of its violent video game ordinance.[79] Though the judge denied admission of the results based on a lack of credibility,[80] there will probably be many future attempts to admit fMRI results. It is important to note that the purpose for which the State of Illinois tried to introduce the fMRI results was not as a lie-detector. Rather, Illinois tried to introduce fMRI evidence to show that certain areas of the brain thought to be associated with increased levels of aggression were more active in adolescents who played video games than those adolescents who did not.[81] Faced with a situation when a person's liberty is at stake, a court is even less likely to admit evidence generated by fMRI until the technique is well-validated.

## V. DEFICITS OF THE TECHNOLOGY IN PARTICULAR SUBPOPULATIONS

Any new technology will need to pass through the evidentiary hurdles discussed above in order to be considered suitable for use in a courtroom setting. In the case of functional brain imaging,

[77] Paul S. Appelbaum, *Law & Psychiatry: The New Lie Detectors: Neuroscience, Deception, and the Courts*, 58 PSYCHIATRIC SERVICES 460, 461 (2007).

[78] *See* Entm't Software Ass'n v. Blagojevich, 404 F. Supp. 2d 1051, 1063–64, 1067 (N.D. Ill. 2005) (finding that the expert testimony presented by the defense as to fMRI testing done was not sufficient to "support the weight [it] attempt[ed] to put on them").

[79] *Id.* at 1063–64.

[80] *Id.* at 1067.

[81] *Id.* at 1063–65.

including fMRI, these challenges will be even more significant than for developments such as recorded voice[82] because the brain is "the least understood organ in [our] body."[83] While we understand that the heart circulates blood by pumping and that the liver secretes certain enzymes that break down fats and toxins, we do not know how the brain produces thoughts, emotions, or ideas.[84] In light of our imperfect knowledge of how the brain works, we do not know if emotions and thoughts might be processed differently in certain subpopulations of humanity.[85] The subpopulations of interest here include pathological liars, the mentally retarded, the brain injured, and those with neurodegenerative diseases.[86] As discussed above, two of the requirements for admitting scientific or technical evidence through expert testimony are that "the testimony [must be] based upon sufficient facts or data, [and] the testimony [must be] the product of reliable principles and methods[.]"[87] For the following subpopulations, it will be difficult at best to develop a reliable data set in order to determine what a "normal" person in the subpopulation looks like when he or she is telling the truth versus when he or she is lying. The reasons vary according to each subpopulation but include the fact that being a member of these subpopulations does not mean that your brain will look like any other member of that subpopulation and certain members of these subpopulations may not even know they are lying.

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[82] *See, e.g.*, Rosoto v. Warden, 83 S. Ct. 1788, 1789 (1963) (admission of electronic voice recordings were upheld without significant controversy because the U.S. Supreme Court denied the application for a certificate of probable cause in habeas corpus proceedings).

[83] Massachusetts General Hospital, The Brain Tumor Center, http://brain.mgh.harvard.edu/btc.htm (last visited Feb. 2, 2009); *see also* Kandel, *supra* note 27, at 16–17 (establishing that the scientific world is only beginning to understand the various functions of the brain regarding behavior and that in the future scientists may "eventually fathom the biological principles [of the brain] that underlie human cognition").

[84] *See generally* Kandel, *supra* note 27, at 349–50.

[85] This is due to experimentation only dealing with normal, cooperative individuals and a lack of experimentation with individuals with preagendas, tendencies to lie, and of a hostile nature. *See* Kozel, *supra* note 55, at 611–12.

[86] *See, e.g.*, *id.* (stating unreliability of fMRIs for liars because the experiments have only been performed on healthy cooperative individuals); *see also* Kandel, *supra* note 27, at 361 (stating how individuals with prefrontal lesions do not respond to environmental stimuli in the same manner that normal individuals do.).

[87] Fed. R. Evid. 702.

*a. Pathological Liars*

Pathological lying is a phenomenon that was first described in the scientific literature more than 100 years ago.[88] However, scientists and clinicians still do not agree on a precise definition of the disorder.[89] A recent article described a diagnosis of pathological lying as appropriate when "the lying is persistent, pervasive, disproportionate, and not motivated primarily by reward or other external factors."[90] In the same paper, the authors described a lack of control over the behavior as central to the condition.[91] Regardless of the precise definition of the disorder, the theories regarding how those afflicted process information and communicate have profoundly disturbing ramifications for the use of fMRI to detect deception in those individuals.

In particular, the theory that pathological liars do not even realize their statements are false could theoretically make the lying "invisible" to fMRI testing because the technology detects differences in brain activity between deceptive behavior and truthful behavior.[92] Accordingly, if the person speaking does not believe he or she is lying, the brain's response would probably not be different from when the person is telling the truth. Another concern is that it is unknown if pathological lying is caused by an organic brain abnormality. One study indicated that up to forty percent of those diagnosed with pathological lying had a history of brain abnormalities.[93] Another study, using single photon emission computed tomography (SPECT),[94] noted dysfunction in a specific brain region in a case study of a pathological liar.[95] Thus, until pathological lying is better understood, fMRI has

[88] Charles C. Dike et al., *Pathological Lying Revisited*, 33 J. AM. ACAD. PSYCHIATRY L. 342, 346 (2005).

[89] *See* Don Grubin, *Commentary: Getting at the Truth about Pathological Lying*, 33 J. AM. ACAD. PSYCHIATRY L. 350, 351 (2005) (showing the various questions still at issue in defining a precise definition of a pathological liar).

[90] *Id.* (citing Dike, *supra* note 88).

[91] Grubin, *supra* note 89, at 342, 344.

[92] Dike et al., *supra* note 88, at 343–44.

[93] B.H. King & C.V. Ford, *Pseudologia Fantastica*, 77 ACTA PSYCHIATRICA SCANDINAVIA 1, 4 (1988).

[94] SPECT is a 3-D imaging technique. *See generally* MayoClinic.com, SPECT scan (Mar. 7, 2007), *available at* http://www.mayoclinic.com/health/spect-scan/CA00084.

[95] Jack G. Modell et al., *Pathological Lying Associated with Thalamic Dysfunction Demonstrated by [$^{99m}$Tc] HMPAO SPECT*, 4 J. NEUROPSYCHIATRY 442, 443, 445 (1992).

little hope of being able to reliably detect deception in these individuals.

*b. Mentally Retarded*

The label "mentally retarded" can be applied to people with widely varying etiologies. "The most common cause of mental retardation" is fetal alcohol syndrome (FAS).[96] Even within this one diagnosis, however, there are a multitude of physical manifestations of the condition.[97] It is known that the damage to the brain caused by maternal consumption of alcohol varies greatly depending upon when in fetal development the alcohol is consumed and the amount of alcohol consumed.[98] In situations where it is necessary for a mentally retarded person to testify during a judicial proceeding, application of fMRI to ensure truthful responses would prove very difficult. The reason is simply that the label fetal alcohol syndrome does not indicate a particular brain structure.[99] The areas of the brain known to be affected by fetal alcohol syndrome include "the basal ganglia, corpus callosum, cerebellum, and hippocampus."[100] Other abnormalities may include altered volume of cortical gray matter and reductions in the power of neuronal firing in the brain.[101] With this constellation of potential brain injuries, it would be extremely difficult to determine what regions of the brain correspond to regions of a "normal" brain for the purposes of associating structure with function. Thus, an examiner would have no way to predict the pattern of brain activity that would indicate lying in a person with fetal alcohol syndrome.

The difficulties outlined for FAS are not unique to that condition. Another example would be Down Syndrome, or trisomy 21.[102] Here, like in the FAS sufferer, there are many

[96] Alison Niccols, *Fetal Alcohol Syndrome and the Developing Socio-Emotional Brain*, 65 BRAIN & COGNITION, 135, 135 (2007).

[97] *Id.* at 136.

[98] *Id.* at 136–37.

[99] *Id.* at 139–40.

[100] *Id.* at 139.

[101] *Id.*

[102] *See* Guimei Yao et al., *Deletion of Chromosome 21 Disturbs Human Brain Morphogenesis*, 8 GENETICS IN MED. 1, 1 (2006) ("Down syndrome (DS), usually caused by trisomy for human chromosome 21 (HSA 21), is a major cause of mental retardation and is characterized by abnormalities of cortical neuroanatomy, neurochemistry, and function.").

potential manifestations of the condition.[103] When one considers that it is difficult at this stage in the development of fMRI to study even relatively simple brain abnormalities such as those associated with visual impairment, the road ahead for use in the mentally retarded seems long indeed.[104]

*c. Environmentally Damaged Individuals*

Detecting deception through the use of fMRI will also prove difficult in people who have suffered some sort of brain injury during their lifetime. There are two ways that this type of damage can occur: physical trauma or mental/emotional trauma.[105] While both types produce potentially fMRI-confounding changes in the brain, they do so in very different ways. In cases of physical damage, the individual was at some point the subject of exterior physical trauma. The trauma can take the form of an impact injury (hit by a car, punched, slipping and striking the head on a stair, etc.) or an exposure to a toxic agent. While it is possible in many cases to identify that something likely happened to the brain of this individual, it is usually not possible to determine the exact changes that occurred.[106] In cases of mental or emotional trauma the problem is even more difficult because unless the person so exposed decides to tell someone about his or her experience(s), there may be no basis for suspecting that anything happened to the individual or that his or her brain may have been affected. Additionally, the idea that mental or emotional trauma alone can cause lasting physical change to the brain is a relatively recent

[103] *See id.* (discussing characterizations of Down Syndrome).

[104] Doron Gothelf et al., *The Contribution of Novel Brain Imaging Techniques to Understanding the Neurobiology of Mental Retardation and Developmental Disabilities*, 11 MENTAL RETARDATION & DEVELOPMENTAL DISABILITIES RES. REV. 331, 337 (2005) (describing the difficulties with using fMRI for the mentally retarded); Printing House for the Blind, What is CVI?, http://www.aph.org/cvi/define.html (last visited Feb. 2, 2009) (showing the simplicity of brain abnormalities associated with visual impairment).

[105] *See generally* Brain Injury Association of America, Causes of Brain Injury, http://www.biausa.org/Pages/causes_of_brain_injury.html (last visited Feb. 2, 2009) (describing the physical causes of trauma to the brain); Barbara Ganzel et al., *The Aftermath of 9/11: Effect of Intensity and Recency of Trauma on Outcome*, 7 EMOTION 227, 227–28 (2007) (describing the mental/emotional causes of trauma).

[106] *See, e.g.,* E. Fortemps et al., *Trimethyltin Poisoning – Report of Two Cases*, 41 INT'L ARCHIVES OCCUPATIONAL. ENVTL HEALTH 1, 1–3 (1978) (explaining how two chemists exposed to dimethyl and tremethyltinchloride showed symptoms of brain trauma, but precise changes could not be found).

development in the scientific community and, as such, the body of literature characterizing this phenomenon is small as compared to the effects of certain physical traumas.[107]

i. Physical Damage

The number of ways a person can sustain brain damage is limited only by one's imagination. For purposes of this note, only the brain damage associated with exposure to trimethyltin (TMT) will be discussed. Trimethyltin was selected because it is an environmentally occurring toxin that leaves little evidence of its presence after it has done its damage and provides a good example of a potentially real-world situation where it may be obvious something happened to a potential witness, but it is unclear exactly what or the nature of the damage.[108] Trimethyltin is a by-product of the manufacture of polyvinyl chloride (PVC) plastics and is used as a barniclecide on the bottom of boats.[109] Exposure to TMT results in a consistent pattern of damage to areas of the brain including the hippocampus and cerebellum as well as a range of physical effects including seizures and death.[110] It is important to note that while the brain structures affected by TMT are consistent, the specific damage that is done, such as amount of tissue destroyed or which specific portions of affected brain regions are destroyed, can vary.[111] Diagnosing TMT exposure is difficult for a primary care physician because of its relatively rare occurrence and the fact that TMT is absorbed through the skin very quickly.[112] The neurological symptoms also do not manifest themselves for several days to several weeks, and during this

[107] Ganzel et al., *supra* note 105, at 228.

[108] *See, e.g.*, M.J. Saary & R.A. House, *Preventable Exposure to Trimethyl Tin Chloride: A Case Report*, 52 OCCUPATIONAL MED. 227, 227–29 (2002) (discussing the effects of, and the difficulty in testing for, trimethyltin poisoning).

[109] The use of TMT as a barniclecide in the US has been banned since 1995 but its use continues in other areas of the world. *See* Marta Michalik et al., *Effects of Trimethyltin on Pinocytosis of Dictyostelium Discoideum*, 40 ACTA PROTOZOOLOGICA 169, 169 (2001); Brian E. Reese et al., *Protein Kinase €′ Regulates Tumor Necrosis Factor-α-Induced Stannin Gene Expression*, 314 J. PHARMACOLOGY & EXPERIMENTAL THERAPEUTICS 61, 61 (2005); *see also* M.M.W. Straiko et al., *Treatment with Trimethyltin Promotes the Formation of Cleaved Tau in the Rat Brain*, 84 J. NEUROSCIENCE RES. 1116, 1116 (2006).

[110] R. Besser et al., *Acute Trimethyltin Limbic-Cerebellar Syndrome,* 37 NEUROLOGY 945, 948, 950 (1987).

[111] Fortemps et al., *supra* note 106, at 4.

[112] *See id.*; Saary & House, *supra* note 108, at 229.

time, other potentially confounding events can occur to explain why the individual is acting differently than he or she used to.[113] Due to the stealthy nature of neuronal damage via TMT exposure and the general nature of some of the symptoms, it is possible that TMT exposure could be misdiagnosed as a psychological problem. If such a person was then subjected to fMRI testing, it would be impossible to compare his or her results to any established control, as his or her brain would be very different from someone's who was not exposed to TMT.[114] Here as well, the danger could lie in false positives or false negatives due to the different physical structure/functional nature of the TMT-exposed brain.

ii. Emotional Trauma

The scientific community has shown that the brain is physically altered in response to intense psychological trauma.[115] This is especially important for the use of fMRI because many of the situations where fMRI's deception detection would be most useful would be in criminal trials, a significant portion of which involve psychological trauma to the victim, and perhaps even the perpetrator. A large body of literature exists showing that severe and/or prolonged periods of stress can cause permanent changes in the human brain.[116] These stresses include "sexual abuse, rape, physical injury, [front line] combat, and natural disasters."[117] The hippocampus and amygdala are essential for the formation and storage of memories, and each is detrimentally affected by the release of stress hormones, potentially to the point of being destroyed by them.[118] Even if the nature or degree

[113] Tsutomu Nishimura et al., *Changes in the GABA-ergic System Induced by Trimethyltin Application in the Rat*, 97 MOLECULAR BRAIN RES. 1, 3, 5–6 (2001).

[114] *See* Reese et al., *supra* note 109, at 61 (discussing alterations that TMT can have on the brain); *see generally* M.L. Billingsley et al., *Functional and Structural Properties of Stannin: Roles in Cellular Growth, Selective Toxicity, and Mitochondrial Responses to Injury*, 98 J. CELLULAR BIOCHEMISTRY 243, 243 (2006) (giving more specific effects of TMT on the brain).

[115] *See, e.g.,* Robert M. Sapolsky, *Glucocorticoids, Hippocampal Damage and the Glutomatergic Synapse*, 86 PROGRESS BRAIN RES. 13, 13, 21 (1990); R. Joseph, *Traumatic Amnesia, Repression, and Hippocampus Injury Due to Emotional Stress, Corticosteroids and Enkephalins*, 29 CHILD PSYCHIATRY & HUM. DEV. 169, 169–70 (1998).

[116] Joseph, *supra* note 115, at 169–70.

[117] *Id.* at 178.

[118] *Id.* at 178–79; Hideo Uno et al., *Hippocampal Damage Associated with Prolonged and Fatal Stress in Primates*, 9 J. NEUROSCIENCE 1705, 1705, 1709–

of trauma is not sufficient to destroy these portions of the brain, studies have shown that the way traumatic stimuli are processed by the brain is different when the stimuli is stressful or traumatic and that processing of subsequent non-traumatic stimuli can be affected by prior traumatic experiences.[119] As a result, the brains of many people who have been exposed to extremely stressful conditions may be different than the brains of those who have not. This may be true even if the stressful situation was short-lived due to a potentially different way of processing the traumatic memories as opposed to non-traumatic memories.

The implications for use of fMRI in many types of criminal trials are profound. In cases involving rape, attempted murder and even, potentially, robbery or assault, the brain of both the victim and the aggressor may be very different from a person who was not exposed to such situations. Accordingly, for these subpopulations of our society, it will be difficult, if not impossible, to adequately test fMRI technology in order to determine how the brain image of a victim (or aggressor) is supposed to look if he or she is telling the truth as opposed to lying.

d. Neurodegenerative Diseases

More than 2.8 million Americans have been diagnosed with either Parkinson's Disease or Alzheimer's Disease, "the two most common neurodegenerative" disorders.[120] Parkinson's Disease is characterized by a "loss of dopaminergic neurons in the substantia nigra . . . pars compacta," resulting in a constellation of physical symptoms including tremor, muscular rigidity, and problems with locomotion.[121] Alzheimer's Disease is caused by

11 (1989); Medline Plus: Medical Dictionary, http://www.nlm.nih.gov/medlineplus/mplusdictionary.html (last visited Feb. 2, 2009) (the hippocampus is "a curved elongated ridge that is an important part of the limbic system . . . and is involved in forming, storing, and processing memory," and the amygdala is "one of four basal ganglia in each cerebral hemisphere that is part of the limbic system").

119 Talma Hendler et al., *Sensing the Invisible: Differential Sensitivity of Visual Cortex and Amygdala to Traumatic Context*, 19 NEUROIMAGE 587, 596–97 (2003).

120 Philip J. Landrigan et al., *Early Environmental Origins of Neurodegenerative Disease in Later Life*, 113 ENVTL. HEALTH PERSP. 1230 (2005).

121 *Id.* For further information on Parkinson's Disease, *see* MayoClinic.com, Parkinson's Disease (May 9, 2008), *available at* http:// www.mayoclinic.com/health/parkinsons-disease/DS00295/ DSECTION=treatments-and-drugs, *and*

the destruction of cortical neurons and the formation of amyloid plaques and neurofibrillary tangles and results in dementia.[122] While people suffering from these diseases are often recognized and diagnosed accordingly, this does not help from the perspective of fMRI testing. Neither of these diseases is completely understood, and the deterioration of brain matter follows no known pattern.[123] Accordingly, use of fMRI as a lie detection technology in people suffering from these conditions will have unpredictable outcomes due to the unpredictable changes occurring in their brains.[124] The high likelihood of false positives and/or false negatives in these subpopulations of society will prevent fMRI testing from being effective as a lie detection tool on people suffering from neurodegenerative diseases.

## VI. CONCLUSIONS

Functional MRI holds great promise for telling us more about how our brains work. The applications of this technology are still being discovered, and advances in genetics, nanotechnology, and mechanical engineering could make fMRI even more useful or powerful in ways we have yet to imagine. However, in order to justify the use of this technology in judicial proceedings, it must meet a very strict evidentiary standard. As this note has described, meeting the *Daubert* standard will be extremely difficult for proponents of fMRI, at least with respect to the specific subpopulations described herein. The economic realities faced by companies and academic investigators developing fMRI technology for use as a lie detector have driven them toward using "normal" people in their validation trials.[125] However,

Answers.com, substantia nigra, http://www.answers.com/topic/substantia-nigra.

122 Landrigan et al., *supra* note 120, at 1230; Kandel et al., *supra* note 27, at 1153–55. For further information on Alzheimer's Disease, see MayoClinic.com, Alzheimer's Disease (Jan. 12, 2007), *available at* http://www.mayoclinic.com/health/alzheimers-disease/DS00161, *and* The American Health Assistance Foundation, Amyloid Plaques and Neurofibrillary Tangles, (Feb. 14, 2008), *available at* http://www.ahaf.org/alzdis/about/AmyloidPlaques.htm.

123 *See* Landrigan et al., *supra* note 120, at 1230 (discussing one hypothesis regarding the cause of Parkinson's Disease and Alzheimer's Disease); *see also* Kandel et al., *supra* note 27, at 1153–55 (discussing various hypotheses regarding causes and progression of Parkinson's Disease and Alzheimer's Disease).

124 *See* Landrigan et al., *supra* note 120, at 1230; Kandel et al., *supra* note 27, at 1153–55.

125 Daniel D. Langleben et al., *Brain Activity During Simulated Deception: An Event-Related Functional Magnetic Resonance Study*, 15 NEUROIMAGE 727,

unless similar validation tests are performed using significant numbers of other subpopulations of people with brain changes or abnormalities, the data generated will not have any transferability or validity as applied to that subpopulation. The reason for this disconnect is the need for the third step in fMRI data analysis where an individual's data is compared to an aggregate signal that is a composite of many previous tests performed on several different individuals.[126] Unless similar composites are created using each of the subpopulations discussed above, there would be no reliable way to interpret fMRI data from them. This would result in the court rejecting admission of fMRI evidence because it would fail the first and/or second prong of the *Daubert* test. The lack of standardization data for groups such as the mentally retarded or for pathological liars will likely lead either to a finding of insufficient facts or data upon which the expert may form his opinion (failing prong 1) or in a finding that the principles upon which the fMRI data is based are not reliable (thus failing prong 2). The issue of determining which group(s) a person should fall into only compounds this problem.

Barring a complete paradigm shift in fMRI development, such as a movement to individually-generated baselines, fMRI testing should only be allowable in very specific situations. As described above, pathological liars may be wholly exempt from testing with fMRI because they do not believe they are lying, and our current knowledge regarding pathological lying is limited as to what may be physically different in individuals with this condition. As a result, fMRI may show that the same regions of a pathological liar's brain "light up" no matter how the person responds to a question.[127] Additionally, use of fMRI in the mentally retarded should probably not be allowed because the range of physical manifestations of mental retardation, even within a particular subgroup such as those suffering from Fetal Alcohol Syndrome, is enormous and not currently amenable to prediction or cataloging. Testing people who have suffered physical trauma to the brain or a neurodegenerative disease is currently difficult if not impossible for the same reasons; there are simply too many

728 (2002); Kozel et al., *supra* note 50, at 295; Kozel et al., *supra* note 53, at 853; Sean A. Spence et al., *Behavioural and Functional Anatomical Correlates of Deception in Humans*, 12 NEUROREPORT 2849, 2849–50 (2001).

[126] *See supra* Part III.b.ii.

[127] Dike et al., *supra* note 88, at 343–44, 348.

possibilities as to how the brain was damaged and how this may affect brain functioning to be confident in predicting how their brains should "light up" on an fMRI test. Also, it would be very difficult to justify using fMRI to sort truth from lie in cases concerning crimes involving emotionally charged situations because it will be unclear how and to what degree the brains of the participants in the case would have been affected by the crime and attendant circumstances. Each of these criticisms ignores a very practical problem in alleviating these concerns, namely, how would one design and implement research studies in these populations of our society? It is difficult to envision a proposal for funding or for project clearance that involves recruiting dozens or hundreds of mentally retarded individuals or emotionally traumatized individuals and subjecting them to rigorous fMRI testing, potentially involving disturbing subject matter, as being met with much enthusiasm.

Indeed these concerns are implicitly admitted by the one corporate entity currently selling fMRI as a lie detection technology, "No Lie MRI."[128] On the company's website, one of the limitations on the use of its technology is that the individual to be tested cannot be brain damaged.[129] While there is no explanation for this limitation on the company's website, this note provides logical reasons for the existence of such a limitation.

As long as the analysis of fMRI data includes a population inference,[130] it will be unsuitable for use in the subpopulations discussed in this note. If fMRI is truly to be a universal lie detector, new ways of obtaining and/or analyzing the data must be developed. While economic realities will constrain research to some degree, it is obvious that not being able to use the technology in emotionally traumatized individuals and other subpopulations will severely limit its attractiveness in a courtroom setting. Additionally, technological advances can further complicate the picture, as evidenced by the development of memory-impairing drugs and their proposed use in preventing post-traumatic stress disorder.[131] Without drastic reform to the

[128] No Lie MRI, *New Truth Verification Technology*, http://www.noliemri.com/index.htm (last visited Feb. 2, 2009).

[129] No Lie MRI, *Process Overview*, http://www.noliemri.com/products/ProcessOverview.htm (last visited Feb. 2, 2009).

[130] Greely & Illes, *supra* note 37, at 383.

[131] Michael Henry et al., *Propranolol and the Prevention of Post-Traumatic*

development of fMRI as a lie detection device, it is destined to become the next polygraph – intriguing but unreliable.

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*Stress Disorder: Is it Wrong to Erase the "Sting" of Bad Memories?*, 7 AM. J. BIOETHICS 12, 12–13 (2007).

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