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TRUTH, DECEIT, AND NEUROIMAGING: CAN FUNCTIONAL MAGNETIC RESONANCE IMAGING SERVE AS A TECHNOLOGY-BASED METHOD OF LIE DETECTION?

*Zachary E. Shapiro**

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* Zachary Evan Shapiro is in his third year at Harvard Law School. A native New Yorker, Zachary received his B.A. in Human Health and Medical Ethics from Brown University in 2009 and an M.Sc. in Biomedicine, Bioscience, and Society in 2012 from the London School of Economics and Political Science. He continued his studies at Harvard Law School in order to pursue his interest in the intersection of law, ethics, and biomedicine.

While at HLS, Zach was a Legal Fellow at Harvard's Multi-Regional Clinical Trials Center, working on projects related to returning clinical trial results, post-trial access, and the ethics of clinical trials. He was awarded a Petrie-Flom Student Fellowship, which allowed him to continue his research into neuroimaging and criminal law. Zachary was a 2015 FASPE Law Fellow, and then spent the summer working in the Department of Bioethics at the National Institutes of Health.

In 2017, Zach will clerk for the Honorable Timothy B. Dyk, on the United States Court of Appeals for the Federal Circuit.

Zachary's current research interests in neuroimaging, criminal law, and lie detection, build upon his prior publications in the field of neuroimaging and neuroethics.

I. INTRODUCTION

The United States legal system places great emphasis on juries, tasking them with determining the credibility of witnesses that testify in court. However, extensive research has found that humans are generally good at lying and quite bad at detecting the lies of others.[1] Studies have found that in face-to-face meetings, the average individual is able to detect deception at a rate only slightly better than 50%, the same rate that would be expected by chance.[2] This has led courts to search for a more objective, technology-based method of lie detection, which could potentially improve on humans' natural ability (or inability) to detect deception.[3]

For much of the twentieth century, the best scientific tool available to detect deception was the polygraph machine.[4] However, studies have cast doubt as to the usefulness of polygraph tests.[5] While one study using meta-analysis found the sensitivity and specificity of the polygraph to be 59% and 92% respectively,[6] a National Academy of Sciences report from 2003 estimated the accuracy of polygraphs to be somewhere in the vicinity of 75%.[7] Crucially, this report found that while accuracy could be as high as 99%, it was often as low as 55%, depending on a variety of factors, such as the operator, setting (i.e., experimental versus forensic), and questioning format.[8] As a result, the National Academy concluded that polygraph testing was largely unreliable.[9]

In recent years, there has been significant enthusiasm for the use of functional magnetic resonance imaging (fMRI) as a scientific tool for lie detection.[10] Functional neuroimaging measures the central nervous system (brain and spinal cord) rather than the peripheral correlates of nervous system activity (heart rate, blood pressure, respira-

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1. *See* ALDERT VRIJ, DETECTING LIES AND DECEIT: PITFALLS AND OPPORTUNITIES 2 (2008).

2. *See* Paul Ekman & Maureen O'Sullivan, *Who Can Catch a Liar?*, 46 AM. PSYCH. 913, 913 (1991) (describing average accuracy in detecting deceit).

3. *See* DAVID LYKKEN, A TREMOR IN THE BLOOD: USES AND ABUSES OF THE LIE DETECTOR 2 (1998).

4. NAT'L RESEARCH COUNCIL, THE POLYGRAPH AND LIE DETECTION 1 (2003).

5. *See, e.g.*, Feroze B. Mohamed et al., *Brain Mapping of Deception and Truth Telling About an Ecologically Valid Situation: Functional MR Imaging and Polygraph Investigation — Initial Experience*, 238 RADIOLOGY 679, 679 (2006) (discussing results of polygraph investigation); NAT'L RESEARCH COUNCIL, *supra* note 4, at 5 (2003).

6. PHILIP E. CREWSON, COMPARATIVE ANALYSIS OF POLYGRAPH WITH OTHER SCREENING AND DIAGNOSTIC TOOLS 2 (2001).

7. NAT'L RESEARCH COUNCIL, *supra* note 4, at 46 (2003).

8. *Id.* at 345.

9. *See* NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES, THE POLYGRAPH AND LIE DETECTION 212–15 (2003).

10. *See* Daniel D. Langleben & Jane Campbell Moriarty, *Using Brain Imaging for Lie Detection: Where Science, Law, and Policy Collide*, PSYCHOL. PUB. POL'Y & L. 222, 222 (2012).

tion, and galvanic skin response), which polygraph testing measures.[11] Brain-based lie detection was pioneered in the late 1980s using electroencephalography ("EEG"),[12] but fMRI is now the preferred modality, due to its ability to localize blood flow in the brain.[13]

Although there is growing enthusiasm for its use, science has only recently begun to investigate fMRI as a method of lie detection. Because the science remains nascent, there are many uncertainties and issues that must be addressed before fMRI can provide truly reliable evidence of truth-telling. These problems create genuine barriers to the current legal admissibility of fMRI lie detection, and must be addressed before this technology can begin to have a regular impact on jurisprudence.

This Note will examine how fMRI technology and associated neuroimaging modalities can be used as a means of lie detection, with an eye towards its potential use in a court of law. Prior articles examining fMRI lie detection have done so without a robust discussion of the technology, focusing instead on the evidentiary problems.[14] However, without an in-depth understanding of the technological and scientific shortcomings of neuroimaging, it is impossible to make accuaccurate conclusions about the applicability of the technology in the legal arena. In Part II, I will discuss fMRI technology in the medical context, before examining fMRI as a potential means of lie detection. In Part III, I will describe limitations of the technology and the available data concerning fMRI lie detection. Understanding these limitations is essential to comprehending the legal issues that arise when using fMRI as evidence, which I will discuss in Part IV. Finally, in Part V, I will examine the specific cases in which fMRI lie detection evidence was offered. While there is genuine promise for fMRI lie detection, without an appropriate understanding of the limitations of this technology at this point in time, we risk advancing a modality that could bring more problems than solutions to the courtroom.

II. AN OVERVIEW OF FUNCTIONAL NEUROIMAGING

Functional neuroimaging (or functional brain imaging) refers to a class of non-surgical devices and methodologies that allow research-

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11. *See id.* at 223.

12. *See* J. Peter Rosenfeld et al., *A Modified, Event-Related Potential-Based Guilty Knowledge Test*, 42 INT'L J. OF NEUROSCI. 157 (1988).

13. S.A. Bunge & I. Kahn, *Cognition: An Overview of Neuroimaging Techniques*, 2 ENCYCLOPEDIA NEUROSCI. 1063, 1065 (2009).

14. *See, e.g.*, Justin Amirian, *Weighing the Admissibility of fMRI Technology Under FRE 403: For the Law, fMRI Changes Everything — and Nothing*, 41 FORDHAM URB. L.J. 715, 718 (2013).

ers to take measurements of an individual's brain activity.[15] While structural neuroimaging, such as computed tomography ("CT") or magnetic resonance imaging ("MRI"), provides images of gross anatomical features, functional neuroimaging demonstrates which areas of the brain are in use.[16] It is based on the observation that when an area of the brain is activated, the magnetic signal in that brain region is increased. This magnetic signal is thought to indicate increased blood flow, which is needed for the brain to perform tasks, such as physical activities, thinking, perceiving, or feeling.[17] Neuroimaging can illuminate these activation patterns, revealing how the brain works in real time.

There is significant interest in the potential applications of fMRI.[18] From 2011 to 2014, there were more fMRI studies published than in the previous seventeen years combined.[19] In addition to scientific implications of fMRI, some have raised the potential for this technology to impact the legal arena.[20] Before one can examine the legal implications of fMRI technology, it is important to understand the science behind this modality.

A. What Is fMRI?

Scientists first began to use fMRI in the early 1990s, and fMRI has since become one of the most widely employed modalities to study the brain.[21] It is important to note that fMRI does *not* measure neuronal activity or firing.[22] Instead, it measures blood flow to regions of the brain that scientists think correlate to neural activation, which occurs when individuals perform any mental task, such as thinking,

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15. Cheryl J. Aine, *A Conceptual Overview and Critique of Functional Neuroimaging Techniques in Humans: I. MRI/fMRI and PET*, 9 CRITICAL REVS. NEUROBIOLOGY 229, 229 (1994).

16. *Id.*

17. *See* Hannah Devlin, *What Is Functional Magnetic Resonance Imaging (fMRI)?*, PSYCH CENTRAL (Jan. 30, 2013), http://psychcentral.com/lib/what-is-functional-magnetic-resonance-imaging-fmri/ [https://perma.cc/H9XW-QZL3].

18. *See, e.g.*, Johannes Stelzer et al., *Deficient Approaches to Human Neuroimaging*, 8 FRONTIERS HUM. NEUROSCI. 1, 1 (2014); Joseph J. Fins & Zachary E. Shapiro, *Neuroimaging and Neuroethics: Clinical and Policy Considerations*, 20 CURRENT OPINION NEUROLOGY 650, 651 (2007).

19. Stelzer et al., *supra* note 18, at 1.

20. Joshua Greene & Jonathan Cohen, *For the Law, Neuroscience Changes Nothing and Everything*, 359 PHIL. TRANSACTIONS ROYAL SOC'Y LONDON 1775, 1775 (2004).

21. *See* Seiji Ogawa et al., *Brain Magnetic Resonance Imaging with Contrast Dependent on Blood Oxygenation*, 87 PROC. NAT'L ACAD. SCI. 9868, 9868 (1990).

22. Neurons are the functional subunit of the brain. *See* Society for Neuroscience, *The Neuron*, BRAINFACTS.ORG (Apr. 1, 2012), http://www.brainfacts.org/brain-basics/neuroanatomy/articles/2012/the-neuron/ [https://perma.cc/VH7N-86XV].

feeling, perceiving, or acting. Thus, fMRI is able to provide an indirect measure of neuronal activation.[23]

Neurons, unlike many cells in the body, do not have internal reserves of energy.[24] Thus, when neurons are activated in response to brain processes, oxygen-rich blood needs to be transported to the neurons. In simple terms, when a region of the brain is "activated" in response to a perception or to enable a behavior, for instance, that region receives more oxygenated blood.[25] This blood flow is referred to as a "hemodynamic response."[26]

Blood that is carrying oxygen behaves differently in magnetic fields than deoxygenated blood: blood that is "near a region of neuronal activity . . . has a higher concentration of oxygenated hemoglobin than blood in locally inactive areas."[27] fMRI measures this difference in the magnetic properties of oxygenated blood in order to detect changes in blood flow. This is called the Blood Oxygen Level Dependent ("BOLD") response.[28] Thinking, perceiving, acting, and feeling have all been shown to correlate with changes in oxygen consumption and regional blood flow in the brain.[29] Measuring differences in BOLD responses, either against a control or against normal-normalized population data, allows researchers to detect differences in signal intensity that indicate the activation or utilization of a particular region of the brain.[30] If the local oxygen use is abundantly supplied by the influx of blood, then a positive BOLD response will result. If the demand for oxygen exceeds the threshold that is provided by regional blood flow, then researchers will measure a negative BOLD response.[31]

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23. *See* Debra A. Gusnard & Marcus E. Raichle, *Searching for a Baseline: Functional Imaging and the Resting Human Brain*, 2 NATURE REVS. NEUROSCI. 685, 691 (2001).

24. *See* Xuchu Weng et al., *Imaging the Functioning Brain*, 96 PROC. NAT'L ACAD. SCI. 11073, 11073 (1999); Teneille Brown & Emily Murphy, *Through a Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant's Past Mental States*, 62 STAN. L. REV. 1119, 1138 (2010).

25. *See* Weng et al., *supra* note 24, at 11073.

26. *See* Karl Friston et al., *Event-Related fMRI: Characterizing Differential Responses*, 7 NEUROIMAGE 30, 30–31 (1998).

27. John T. Cacioppo et al., *Just Because You're Imaging the Brain Doesn't Mean You Can Stop Using Your Head: A Primer and Set of First Principles*, 85 J. PERSONALITY & SOC. PSYCHOL. 650, 651 (2003) (citing John T. Cacioppo & G.G. Berntson, *Social Psychology Contributions to the Decade of the Brain: Doctrine of Multilevel Analysis*, 47 AM. PSYCHOLOGIST 1019 (1992)).

28. Seiji Ogawa and colleagues labeled this enhancement the "BOLD contrast." *See* Ogawa, *supra* note 21; *see also* Marcus E. Raichle & Mark A. Mintun, *Brain Work and Brain Imaging*, 29 ANN. REV. NEUROSCI. 449, 455 (2006).

29. *See* Yohan John, *What Does fMRI Measure, Anyway?*, NEUROLOGISM (Jan. 23, 2013), https://neurologism.com/2013/01/23/what-does-fmri-measure-anyway/ [https://perma.cc/RF4R-AG2G].

30. *See* Joseph R. Simpson, *Functional MRI Lie Detection: Too Good to Be True?*, 36 J. AM. ACAD. PSYCHIATRY L. 491, 492 (2008).

31. *See* Alex R. Wade, *The Negative BOLD Signal Unmasked*, 36 NEURON 993, 993 (2002).

These changes in the blood oxygenation level are measured in a spatial volume, in order to create a three-dimensional image of the brain.[32] Each 3D unit reflects a tiny cube of brain tissue, and is called a voxel.[33] Each voxel is a unit of volume, and in the brain, a voxel represents millions of brain cells.[34] The active illuminated parts of the brain on an fMRI image represent activation or deactivation of hundreds of clusters of voxels.[35] fMRI machines do not take instant photos like a digital camera, as blood flow through the brain is so fast, and so biologically small, that even the best scanners must take many photos.[36] Thus the images produced show blood flow through the brain over a short time, rather than at any one instant.

The difference in BOLD response is ultimately what is most relevant to researchers employing fMRI.[37] If we accept that changes in blood flow correlate to changes in local brain activation,[38] then we can begin to understand how fMRI is thought to measure and create an image that serves as an illuminating proxy for brain activity. However, as discussed below, while fMRI records brain activity that occurs in parallel with mental or physical behavior, thereby establishing correlation, fMRI cannot demonstrate a causal connection (e.g., that a particular activation pattern causes a parallel instance of a specific behavior, thought, etc., or vice versa).[39]

As fMRI measures blood flow, its data would be useless without an understanding of the anatomy of the human brain. Prior research has been essential in identifying certain functional subunits of the brain.[40] By comparing blood flow to different regions of the brain, combined with our prior understanding of the role that different areas of the brain play in complex tasks, such as cognition, fMRI data is able to contribute to a map of brain activity.[41]

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32. *See* Daisy Yuhas, *What's a Voxel and What Can It Tell Us? A Primer on fMRI*, SCI. AM. (June 21, 2012), http://blogs.scientificamerican.com/observations/whats-a-voxel-and-what-can-it-tell-us-a-primer-on-fmri/ [https://perma.cc/94AF-LXYR].

33. *Id.*

34. *Id.*

35. *See* Edson Amaro Jr. & Gareth J. Barker, *Study Design in fMRI: Basic Principles*, 60 BRAIN & COGNITION 220, 221–23 (2006).

36. William A. Woodruff, *Evidence of Lies and Rules of Evidence: The Admissibility of fMRI-Based Expert Opinion of Witness Truthfulness*, 16 N.C. J.L. & TECH. 105, 117 (2014).

37. *See* Gary Glover, *Overview of Functional Magnetic Resonance Imaging*, 22 NEUROSURGERY CLINICS N. AM. 133, 134–35 (2011).

38. This is a potentially problematic assumption that will be addressed later in this Note.

39. *See generally* Russell A. Poldrack, *Neuroimaging: Separating the Promise from the Pipe Dreams*, DANA FOUND. (May 27, 2009), http://www.dana.org/Cerebrum/2009/Neuroimaging_Separating_the_Promise_from_the_ Pipe_Dreams/ [https://perma.cc/S8RC-MPFE].

40. *See* Rosaleen A. McCarthy & E.K. Warrington, *Evidence for Modality-Specific Meaning Systems in the Brain*, 334 NATURE 428, 428 (1998).

41. For an explanation of why a brain activity map is important, see Elizabeth Landau, *Brain Map Seeks To Unlock Mysteries of the Mind*, CNN (Mar. 7, 2013), http:// cnn.com/2013/03/07/health/brain-activity-map/ [https://perma.cc/73RP-BJ8J].

B. fMRI as a Method of Lie Detection

Scientists have become increasingly confident that they can eventually utilize fMRI data to determine whether an individual is lying.[42] In order to use fMRI for lie detection, researchers design experiments in which BOLD activity is measured under conditions in which individuals are instructed or permitted to make deceptive or truthful statements.[43] In most experiments, individuals are instructed to tell the truth in specific trials and then to lie in others.[44] The activation in different trials is then contrasted to a baseline control in that individual.[45] The regions showing significantly greater activation for lies than for truth have been understood to be neural correlates of deception.

Crucially, there was no single region of the brain that was always active when different subjects lied, indicating the variability and unknowns that remain.[46] However, a recent meta-analysis found that the bilateral dorsolateral and ventrolateral prefrontal cortex,[47] inferior parietal lobule,[48] and anterior insula[49] in the brain were active during deception at a much higher statistical rate than chance.[50] Researchers found a pattern suggesting that "in the future functional neuroimaging may be used to detect deception in situations that have significant societal consequence, e.g., legal proceedings."[51] Indeed, under specific, controlled laboratory conditions, fMRI has been able to distinguish lies from the truth in individual subjects with 76% to 93% accuracy.[52]

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42. *See* Steven K. Erickson, *Blaming the Brain*, 11 MINN. J.L. SCI. & TECH. 27, 29 (2010).

43. *See* Daniel D. Langleben et al., *Brain Imaging of Deception*, *in* NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM (Joseph R. Simpson ed., 2012); Daniel D. Langleben, *Detection of Deception with fMRI: Are We There Yet?*, 13 LEGAL & CRIMINOLOGICAL PSYCHOL. 1, 2–5 (2008); Sean A. Spence & Catherine J. Kaylor-Hughes, *Looking for Truth and Finding Lies: The Prospects for a Nascent Neuroimaging of Deception*, 14 NEUROCASE 68, 71–72 (2008).

44. *See* Simpson, *supra* note 30, at 492.

45. *Id.* at 492–93.

46. *See* Martha J. Farah et al., *Functional MRI-Based Lie Detection: Scientific and Societal Challenges*, 15 NATURE REVS. NEUROSCI. 123, 124 (2014).

47. A brain region thought to be responsible for higher-order processing and thinking. *See* Rebecca Elliott, *Executive Functions and Their Disorders*, 64 BRITISH MED. BULL. 49, 51–52 (2003).

48. A brain region thought to be responsible for perception and interpretation of emotion and sensory information. *See* Victoria Singh-Curry & Masud Husain, *The Functional Role of the Inferior Parietal Lobe in the Dorsal and Ventral Stream Dichotomy*, 47 NEUROPSYCHOLOGIA 1434, 1445 (2009).

49. A brain region thought to be responsible for a variety of social, emotional, and motor functions. *See* Sandra Blakeslee, *A Small Part of the Brain, and Its Profound Effects*, N.Y. TIMES (Feb. 6, 2007), http://www.nytimes.com/2007/02/06/health/psychology/06brain.html (last visited May 4, 2016).

50. Farah et al., *supra* note 46, at 124.

51. Sean A. Spence et al., *If Brain Scans Really Detected Deception, Who Would Volunteer to Be Scanned?*, 55 J. FORENSIC SCI. 1352, 1352 (2010).

52. Daniel D. Langleben et al., *Telling Truth from Lie in Individual Subjects with Fast Event-Related fMRI*, 26 HUM. BRAIN MAPPING 262, 267 (2005); F. Andrew Kozel et al.,

Such studies help explain the recent enthusiasm for fMRI-based lie detection.

Any plan to introduce technological data in the legal arena, where science generally must be both reliable and relevant in order to be admissible, must take into account the limitations and shortcomings of the technology.[53] While some of the issues discussed below may seem minor, any scientific uncertainty will be pushed into sharp focus in a legal context, where issues of due process, prejudicial information, and the need for complex science to be interpreted by laypeople are major concerns.

III. fMRI LIE DETECTION SCIENCE IS NOT YET READY TO BE USED IN A LEGAL SETTING

Although the number of studies using fMRI has skyrocketed,[54] there are limitations arising out of the currently available data.[55] These limitations cast doubt as to the broad applicability of fMRI data as a scientific method of lie detection. Some of the limitations of fMRI technology are germane to all applications of fMRI, while others are more specific to its use in the legal arena.

A. Deficiencies in Currently Available fMRI Data

A key limitation of fMRI data concerns the issue of generalizing from studies that are typically conducted with small numbers of participants. Indeed, some influential fMRI studies have been conducted with only a handful of subjects,[56] and some have been improperly generalized to a larger population.[57] Modern clinical trials recruit as many participants as possible so that the most accurate and statistically valid results can be found.[58] While a lack of statistical power may seem like a purely academic concern, it can have tremendous consequences if a criminal investigation or trial relies upon such data. With

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Detecting Deception Using Functional Magnetic Resonance Imaging, 58 BIOLOGICAL PSYCHIATRY 605, 609–10 (2005).

53. *See* R. Thomas Roberts, et al., *From Frye to Daubert: What You Need to Know About Admitting Expert Testimony in Florida State Courts*, MARSHALL DENNEHEY WARNER COLEMAN & GOGGIN, P.C. (Dec. 17, 2013), http://www.marshalldennehey.com/defense-digest-articles/frye-daubert-what-you-need-know-about-admitting-expert-testimony-florida [https://perma.cc/4NJ4-RSPS].

54. *See* Eric Racine et al., *fMRI in the Public Eye*, 6 NATURE REVS. NEUROSCI. 159, 159–60 (2005).

55. *See* Michael Shermer, *Why You Should Be Skeptical of Brain Scans*, 19 SCI. AM. MIND 67, 68–71 (2008).

56. *See generally* Farah et al., *supra* note 46, at 126.

57. *See id.*

58. *See* SCOTT A. HUETTEL ET AL., FUNCTIONAL MAGNETIC RESONANCE IMAGING 451 (2009).

insufficient statistical power, it becomes impossible to establish whether the results of an experiment are a statistical aberration or a genuine finding that will hold true for all individuals.

The hardware used in this technology poses additional challenges. The fMRI machine is very large and requires specialized space and power requirements — not only for the machine, but also for the processing computers and data capturing units.[59] Furthermore, fMRI machines are expensive to buy and maintain.[60] And while fMRI is non-invasive, conducting a scan is time consuming and requires specialized technicians.[61] Taken together, these factors have led many neuroimaging experiments to utilize subject groups that were selected not due to concerns related to statistical power, but rather due to more practical concerns, such as how much scanning time, space, and money has been allocated to the experiment.[62] These factors also help explain why so many studies focusing on fMRI have small participant groups, and are therefore underpowered, lacking the statistical relevance needed to generalize results to the larger population.[63]

A further issue is that fMRI can succeed only in precise laboratory conditions.[64] Because participants are required to lie still in a very small, doughnut-shaped space, there is a limit to what tasks and activities they can be expected to perform. It is also currently impossible to remove any inherent bias or cognitive effects that lying in a giant scanner may have on typical behavior. This means that fMRI may not accurately tell us about the human brain under normal conditions, as it takes images of a brain under conditions that are far from regular. Such experimental design also limits the applicability of fMRI experiments, as it is currently impossible to fully replicate real world experiences in an fMRI machine.[65]

Also problematic is the establishment of normative data. In order to discern the normal from the abnormal brain, researchers use fMRI to make activation maps from a control group.[66] These results are

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59. *See* Lacie Glover, *Why Does an MRI Cost So Darn Much?*, TIME (July 16, 2014), http://time.com/money/2995166/why-does-mri-cost-so-much/ [https://perma.cc/3H2H-WCDB].

60. *See id.*

61. Glover, *supra* note 37, at 136; MATT CARTER & JENNIFER SHIEH, GUIDE TO RESEARCH TECHNIQUES IN NEUROSCIENCE 25 (2d ed. 2015).

62. *See* Brown & Murphy, *supra* note 24, at 1150.

63. For an explanation of the importance of statistical power, see Alex Coppock, *10 Things You Need to Know About Statistical Power*, EGAP (Nov. 20, 2013), http://egap.org/methods-guides/10-things-you-need-know-about-statistical-power [https://perma.cc/SN59-CN66].

64. *See generally*, Joseph B. Mandeville & Bruce R. Rosen, *Functional MRI*, *in* BRAIN MAPPING: THE METHODS 315, 315–24 (2d ed. 2002).

65. *See* Brown & Murphy, *supra* note 24, at 1186.

66. Max Coltheart, *What Has Functional Neuroimaging Told Us About the Mind (So Far)?*, 42 CORTEX 323, 323 (2006); Brown & Murphy, *supra* note 24, at 1149.

added together and then averaged.[67] This averaged data is presented as normal, even though no single individual tested may actually conform to the average of the group.[68] The "normal" group map is then contrasted to the data taken from the individual in question, which is usually the result of many discrete trials that are averaged together. This is done in order to establish whether or not the individual in question can be considered normal or, to a certain degree, abnormal, with respect to a given task.[69]

This is problematic from both a medical and legal perspective. Increasingly, research has shown that variance in brain imaging and neuroanatomy may be the norm rather than the exception.[70] Brain anatomy varies significantly between different individuals, especially in cortical areas that control higher brain function.[71] This could mean that any comparison to group data is inappropriate, as the relevance of group data regarding brain scans would be limited if every individual is expected to present unique variations. Because the creation of group data requires identifying specific shared neural activations, researchers may not recognize legitimate differences between subjects, as such differences could be attributed to statistical noise or background.

Interpretation of neuroimaging data is severely hampered by this issue of "group to individual" inference, which scholars have dubbed the "G2i" problem.[72] Applying data from a group of test subjects to any one individual is challenging due to expected differences and variances among the subjects.[73] Currently, most neuroimaging studies, and applications of neuroimaging in criminal law, suffer from the G2i problem, as the experiments are generally conducted with a group of subjects.[74] While scholars have written about how to ameliorate the G2i problem in evidentiary analysis,[75] a full discussion of this topic is beyond the scope of this paper. Rather, what is important is that the G2i issue further limits the legal relevance of current neuroimaging data.

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67. *See* Bernard Baertschi, *Neuroimaging in the Courts of Law*, 3 J. APPLIED ETHICS & PHIL. 9, 10–11 (2011).

68. *See id.*

69. *See id.*

70. Stephan Hamann & Turhan Canli, *Individual Differences in Emotion Processing*, 14 CURRENT OPINION NEUROBIOLOGY 233, 233 (2004).

71. *See, e.g.*, Gabriele Lohmann & D. Yves von Cramon, *Automatic Labelling of the Human Cortical Surface Using Sulcal Basins*, 4 MED. IMAGE ANALYSIS 179, 179 (2000) (explaining that one of the "intriguing problems in [the field of human brain mapping] is the high interpersonal variability of human neuroanatomy which makes studies across many subjects difficult").

72. David L. Faigman et al., *Group to Individual (G2i) Inference in Scientific Expert Testimony*, 81 U. CHI. L. REV. 417, 420 (2014).

73. *See id.* at 421.

74. *See id.* at 419–22.

75. *See generally id*.

B. fMRI Data Faces Challenges Before It Can Be Admitted in the Legal Arena

Many of the shortcomings discussed above become especially problematic if we try to bring fMRI experiments into the criminal legal context, where science faces extreme scrutiny before it can be admitted.[76] Courts are especially sensitive about a lack of scientific consensus, particularly because those engaging with the information in a legal setting will generally lack the scientific expertise needed to properly understand the limitations of these studies.[77] This is a clear problem if neuroimaging is brought into a courtroom, where laypeople, including judges and juries, will be confronted with fMRI evidence.

It is presently impossible to perform studies that truly assess and recreate the conditions under which criminality occurs.[78] It is particularly problematic to recreate the conditions of extreme stress that are likely to occur during the undertaking of criminal action.[79] Since fMRI tests rely on lab-controlled experiments,[80] the applicability of these tests to the tense and dynamic environment in which a crime occurs is limited. Because criminal law is primarily concerned with the mindset of the defendant prior to and during the commission of the crime,[81] the data provided by fMRI may be of limited legal significance.

A further limitation, touched on above, is the limited available data on what "normal" brain activity looks like.[82] This is especially important if neuroimages are to carry weight in a criminal law setting, as data concerning an individual's mindset is of little value without a "normal" data set with which it can be compared. Such comparisons will be essential for defense attorneys, who might want to introduce neuroimages as evidence that their clients were not functioning as normal individuals. They may also be important for prosecutors, who could be interested in evidence that demonstrates that an individual's neuroimages do not fall outside the norm, potentially increasing that individual's culpability in the eyes of the law.

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76. *See generally* TELLUS INSTITUTE, DAUBERT: THE MOST INFLUENTIAL SUPREME COURT RULING YOU'VE NEVER HEARD OF (2003), http://www.phil.vt.edu/dmayo/personal_website/PhilEvRelReg/Daubert-The-Most-Influential-Supreme-Court-Decision-You-ve-Never-Heard-Of-2003%201.pdf [https://perma.cc/2C62-25RC].

77. *See id.*

78. *See* Brown & Murphy, *supra* note 24, at 1186.

79. *See* Guy C. Van Orden *&* Kenneth R. Papp, *Functional Neuroimages Fail to Discover Pieces of Mind in the Parts of the Brain*, 64 PHIL. SCI. PROC. S85, S87 (1997); Brown & Murphy, *supra* note 24, at 1167.

80. *See* Glover, *supra* note 37, at 134–35.

81. *See* RANETA LAWSON MACK, A LAYPERSON'S GUIDE TO CRIMINAL LAW 134 (1999).

82. *See* Van Orden & Papp, *supra* note 79, at S88; Brown & Murphy, *supra* note 24, at 1148–52.

The fact that interpretation of fMRI studies may lead to improper conclusions complicates the issue of their legal admissibility. For any scientific study to be admissible, it must be clear that the data is relevant to the individual.[83] If no two people are expected to have the same brain scans, it is unclear how relevant any comparison to a group would be. This would cast doubt on an attempt by a defense attorney or prosecutor to use fMRI studies to show that an individual falls outside of the "normal" brain activity map, since nobody would be expected to be an ideal fit. In fact, such an "ideal fit" may not even exist, as the data results from averages of trials, rather than any individual image that shows real world, non-analyzed results.

The paucity of normative data is magnified by the total absence of group-specific neuroimaging data, essential to ensuring that the studies fit any particular defendant. Few comprehensive studies have investigated differences in functional neuroimaging responses across gender, race, age, or handedness (which has a significant impact on brain studies). These and other factors could contribute to expected, or "normal," variations in fMRI or other neuroimaging modalities.[84]

There are further risks involved in interpreting an individual as abnormal based on current fMRI science. First, there is no way to establish that individuals in the control group have normal brains.[85] Indeed, the expectation should be that each control member would have some level of unique difference, if not pathology. It is also possible that an individual, who has never performed poorly on any cognitive or physiological tests, could have unique brain activity due to a different learning style, cognitive strategy, or some unique element that produced a different result during the scan.[86] We then run the risk of assigning legal weight to a conclusion that an individual's results are abnormal, because they do not match the brain scans of their peers, without truly establishing this from a medical perspective. These issues are compounded by the small control group sizes discussed above. Under these conditions, even limited variance in control group members' brain scans would have disproportionate effects on the study outcomes.

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83. *See* Ronald E. Gots, *Relevance or Fit: A Key Element of Daubert*, DRI TODAY (Mar. 9, 2009), http://dritoday.org/post/Relevance-or-Fit-A-Key-Element-of-Daubert.aspx [https://perma.cc/NR2B-T2BN].

84. *See, e.g.*, Alan Evans, *The NIH MRI Study of Normal Brain Development*, 30 NEUROIMAGE 184, 184–86 (2006); Jennifer L. Cuzzocreo et al., *Effect of Handedness on fMRI Activation in the Medial Temporal Lobe During an Auditory Verbal Memory Task*, 30 HUMAN BRAIN MAPPING 1271, 1276 (2009).

85. *See* Thomas Armstrong, *The Myth of the Normal Brain: Embracing Neurodiversity*, 17 AMA J. ETHICS 348, 349 (2015).

86. *See* Aaron Alexander-Bloch et al., *Imaging Structural Co-Variance Between Human Brain Regions*, 14 NATURE REVS. NEUROSCI. 322, 323 (2013); *see* Brown & Murphy, *supra* note 24, at 1150–52.

In addition to understanding the limitations of the technology, there are issues with study design that must be addressed before criminal courts should admit fMRI technology for lie detection. Laboratory experiments proceed under the assumption that the participant is complying with researcher instructions.[87] This assumption generally holds true because there is often no reason for an individual to deceive researchers. This is not the case in a potential criminal trial. Indeed, it is easy to imagine that individuals will try to "deceive" the fMRI, either intentionally or unintentionally (due to changes in one's emotional state associated with the stress of a trial and the preserved importance of doing "well" on the test).

Potential countermeasures[88] could allow an individual to "trick" an fMRI machine, including thinking of non-relevant stimuli while in the fMRI machine or refusing to properly comply with researcher instructions.[89] Interestingly, one study examined countermeasures as simple as moving a finger or toe imperceptibly (i.e., without any overt movement that could be observed).[90] These simple movements, imperceptible to those conducting the experiment, were sufficient to trigger brain activation patterns that substantially reduced the accuracy of the fMRI deception test.[91] Given the effectiveness of the countermeasures in a laboratory environment, it is likely that countermeasures will be even more effective in a situation where an individual has a real stake in the outcome of the test, as would be the case if the test were administered for use in a courtroom.[92] Furthermore, it is unknown whether individuals could "prime" themselves in advance of taking fMRI lie detector tests by, for instance, repeating a lie so many times that the brain begins to show activation patterns associated with repetitive conduct, rather than deception. While recent studies suggest certain countermeasures could be overcome,[93] this remains a major problem when trying to generalize results from current fMRI lie detection experiments to real world applications.

This is far from an exhaustive list of the problems fMRI lie detection evidence would face in a hearing regarding admissibility. There is also the question of how useful an fMRI lie detector would be in individuals who are deceiving themselves, who have a mental illness, or who display sociopathic tendencies, especially with regard to truth-

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87. *See* Woodruff, *supra* note 36, at 204.

88. Countermeasures are actions taken in response to an event or test in order to counter or negate the results.

89. *See* Giorgio Ganis et al., *Lying in the Scanner: Covert Countermeasures Disrupt Deception Detection by Functional Magnetic Resonance Imaging*, 55 NEUROIMAGE 312, 313 (2011).

90. *See id.*

91. *See id.* at 317–18.

92. *See id.* at 318.

93. *See generally* Howard Bowman et al., *Countering Countermeasures: Detecting Identity Lies by Detecting Conscious Breakthrough*, 9.3 PLOS ONE 1 (2014).

telling behavior.[94] Furthermore, deception is not a homogeneous behavior, as there are many types, gradations, and motivations for not telling the whole truth.[95] Different types of lying may have different neural correlates, which could confound anyone trying to generalize fMRI results to create a specific image of what a "lying" brain looks like.[96] Stress level, degree of rehearsal, and many other factors could also influence neuroimaging techniques in ways we do not fully understand.[97] This is especially true in a non-experimental setting, where the participant has a vested interest in the outcome of the fMRI study.[98] Furthermore, there may be differences in the lying brain that can result from unique pathologies, cultural backgrounds, or other factors that could prevent these studies from being able to maintain high levels of accuracy across different test subjects.

IV. UNDER CURRENT LAW, FMRI EVIDENCE IS, AND SHOULD BE, INADMISSIBLE

Despite the limitations detailed above, genuine interest persists in incorporating neuroimaging advances into jurisprudence.[99] Intrepid defense lawyers continue to introduce neuroimaging evidence in criminal proceedings, and there are indications that many view neuroimaging as a game-changer for criminal law.[100] However, despite some scholarship arguing otherwise,[101] neuroimaging is likely to face strong resistance, if not complete exclusion, under both the Federal Rules of Evidence and commonly accepted evidentiary tests regarding expert opinion and scientific evidence.

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94. *See* Baertschi, *supra* note 67, at 12.

95. *See generally* SISSELA BOK, LYING (2d ed. 1999); J.A. BARNES, A PACK OF LIES: TOWARDS A SOCIOLOGY OF LYING (1994).

96. For example, it is unknown whether different types of lying, such as lying for personal gain, lying to spare the feelings of another, lying to ourselves, lying we consider trivial, and lying by omission, to name but a few, have the same type of neural correlates. *See* Giorgio Ganis, *Neural Correlates of Different Types of Deception: An fMRI Investigation*, 13 CEREBRAL CORTEX 830 (2003).

97. *See generally* Frank Andrew Kozel et al., *A Replication Study of the Neural Correlates of Deception*, 118 BEHAV. NEUROSCI. 852, 852–56 (2004).

98. *See* Simpson, *supra* note 30, at 494.

99. *See* Adam Teitcher, *Weaving Functional Brain Imaging into the Tapestry of Evidence: A Case for Functional Neuroimaging in Federal Criminal Courts*, 80 FORDHAM L. REV. 355, 358 (2011).

100. *See* Deborah J. Daniels, Assistant Attorney Gen., Dep't of Justice, The Future is Now: Reducing Victimization Through Advances in Criminal Justice Techniques at the American Society of Criminology 54th Annual Meeting (Nov. 13, 2002) (endorsing many new technologies, including fMRI, as "absolutely critical" to the criminal justice system).

101. *See* Teitcher, *supra* note 99.

A. Daubert and FRE 702

For much of the twentieth century, the seminal case regarding the evidentiary admissibility of scientific opinions was *Frye v. United States*, a 1923 case in the D.C. Circuit, which upheld the exclusion of the results of a "systolic blood pressure deception test," a primitive version of a lie detector test.[102] The D.C. Circuit held that admissibility of a "scientific principle or discovery" depends on whether the science in question is "sufficiently established to have gained general acceptance in the particular field in which it belongs."[103]

While this evidentiary standard was the dominant test for admissibility of scientific evidence for decades, in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, the Supreme Court declared that Federal Rule of Evidence ("FRE") 702 superseded the "general acceptance" test from *Frye*.[104] In *Daubert*, the Court held that the appropriate standard for scientific admissibility was FRE 702, which demanded that scientific testimony be "not only relevant, but reliable."[105]

In an opinion joined by six other Justices, Justice Blackmun identified five key factors that judges should consider when ruling on admissibility of scientific evidence: (1) "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 scientific technique; (4) "the existence and maintenance of standards controlling the technique's operation;" and (5) "general acceptance" in the "relevant scientific community."[106] The Court intended this test to be flexible and noted that the specific factors were not to be considered a "definitive checklist."[107]

Daubert has been incorporated into FRE 702 in recent revisions and amendments.[108] Currently, FRE 702 reads:

> A witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if: (a) the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue; (b) the testimony is based on sufficient facts or data; (c)

102. 293 F. 1013, 1014 (D.C. Cir. 1923).
103. *Id.*
104. 509 U.S. 579, 585, 587, 589 (1993).
105. *Id.* at 589.
106. *Id.* at 592–94.
107. *Id.* at 593–94.
108. FED. R. EVID. 702 advisory committee's note ("Rule 702 has been amended in response to *Daubert v. Merrell Dow Pharmaceuticals, Inc.* . . .").

> the testimony is the product of reliable principles and methods; and (d) the expert has reliably applied the principles and methods to the facts of the case.[109]

These standards are similar to the ones set forth by Justice Blackmun, and while *Daubert* has been refined and clarified in subsequent cases,[110] the factors listed above are the most relevant for our inquiry into whether neuroimaging evidence will be admissible under current evidentiary standards.

Daubert is clearly the correct standard under which to assess neuroimaging evidence.[111] fMRI studies for many applications seem to be able to withstand *Daubert* challenges: it is a valid research tool, has generally been accepted by scientists, is subject to peer review and publication, and is often testable and refutable. In theory, the research methods can be replicated, and rely on theories that can be tested for error rates.[112]

However, decisions subsequent to *Daubert* clarified that expert testimony is relevant only if the data on which the expert relies is an appropriate "fit" to the facts of the case at hand.[113] Essential to fit is that there is a logical nexus between the conclusions and the data, and that the scientific methods and data are valid for the particular purpose for which the evidence is being admitted.[114] Thus, for example, studies that demonstrate neuroimaging's utility for identifying brain regions in advance of neurosurgery would not be relevant to, nor would they impact the admissibility of, neuroimaging studies introduced as a form of lie detection.[115] Similarly, such studies would not vitiate mens rea claims.[116] This principle recognizes that "scientific validity for one purpose is not necessarily scientific validity for other, unrelated purposes."[117]

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109. FED. R. EVID. 702.

110. *See* Jennifer L. Groscup et al., *The Effects of* Daubert *on the Admissibility of Expert Testimony in State and Federal Criminal Cases*, 8 PSYCHOL. PUB. POL'Y & L. 339, 339 (2002).

111. *See* Brown & Murphy, *supra* note 24, at 1172.

112. For the importance of error rates and replicability, see, for example, Groscup et al., *supra* note 110, at 341 (restating the *Daubert* factors).

113. *See* General Elec. Co. v. Joiner, 522 U.S. 136, 146 (1997).

114. *See* Alice B. Lustre, Annotation, *Post-Daubert Standards for Admissibility of Scientific and Other Expert Evidence in State Courts*, 90 A.L.R.5th 453 (2001) (noting that New Hampshire considers "logical nexus" in determining "fit" or reliability of expert testimony); Brown & Murphy, *supra* note 24, at 1177.

115. *See generally* Victor E. Schwartz & Cary Silverman, *The Draining of* Daubert *and the Recidivism of Junk Science in Federal and State Courts*, 35 HOFSTRA L. REV. 217, 218 (2006).

116. *See id.*

117. *See* Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 591 (1993).

B. fMRI and FRE 702

The most intriguing courtroom applications of neuroimaging using fMRI are not sufficiently reliable to be admitted as evidence in a criminal court. fMRI has not been shown to reliably determine complex retrospective mental states in an individual subject, which would be necessary to utilize fMRI to explore mens rea. Currently, it is extremely difficult to find even one widely-respected researcher who supports the use of functional neuroimaging to assess past mental states in a criminal law setting, meaning this specific use has certainly not gained widespread scientific acceptance.[118] This lack of acceptance does not affect the potential of fMRI as a method of lie detection. However, despite some enthusiasm, there is insufficient research at this point to claim that fMRI for lie detection is generally accepted or scientifically valid, as questions of error rate and relevance still loom large.[119]

It is also unclear whether some neuroimaging findings can be reliably reproduced, which is considered a key feature of the *Daubert* analysis.[120] There are still significant unknowns surrounding the BOLD response and the underlying information that fMRI machines measure. Furthermore, there are disputes concerning the applicability of fMRI laboratory experiments to real world situations or to factors of criminality.[121]

These factors combine to cast serious doubt on the reliability of neuroimaging studies from a *Daubert* admissibility standard, meaning acceptance could be withheld even though fMRI has gained "widespread acceptance" in other contexts in the scientific community.[122] Despite the enthusiasm in the scientific, lay, and defense council community,[123] many scholars would concede that, at this stage, neuroimaging is not ready for prime time impact in a court of law.[124]

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118. *See* Brown & Murphy, *supra* note 24, at 1178.

119. *See* Woodruff, *supra* note 36, at 199.

120. *See* Gio Batta Gori, Letter, Daubert*'s Menace*, 96 AM. J. PUB. HEALTH 206, 206 (2006).

121. *See generally* Woodruff, *supra* note 36, at 191.

122. Examples of scientific contexts in which fMRI has gained widespread acceptance include imaging neuroanatomy, planning neurosurgery, and diagnosing brain trauma. *See* Brown & Murphy, *supra* note 24, at 1177.

123. *See, e.g.*, Owen D. Jones et al., *Brain Imaging for Legal Thinkers: A Guide for the Perplexed*, 5 STAN. TECH. L. REV. 81, 81–84 (2009); Joshua Greene & Jonathan Cohen, *For the Law, Neuroscience Changes Nothing and Everything*, 359 PHIL. TRANSACTIONS ROYAL SOC'Y LONDON 1775, 1775 (2004).

124. *See, e.g.*, Stephen J. Morse, *Avoiding Irrational NeuroLaw Exuberance: A Plea for Neuromodesty*, 62 MERCER L. REV. 837 (2011); ALVA NOË, OUT OF OUR HEADS: WHY YOU ARE NOT YOUR BRAIN, AND OTHER LESSONS FROM THE BIOLOGY OF CONSCIOUSNESS (2009).

C. fMRI and FRE 403

Even if neuroimaging is one day able to pass scrutiny under *Daubert* and FRE 702, as some scholars seem to think is inevitable,[125] the evidence could still be excluded under FRE 403, which dictates that evidence should be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury.[126] The question of whether the probative value of neuroimaging evidence would be outweighed by its prejudicial effects is a topic of substantial scholarly debate.[127] There is serious concern about the potential problems that neuroimaging will present to fact-finders, who as laypeople will be hard pressed to grasp the true scientific, statistical, and analytic complexities of fMRI technology and its accompanying data.

While researchers have warned that there is the "potential for brain scan images to create biases in the laboratory, the clinic and the courtroom,"[128] studies have provided conflicting information as to whether this prejudicial effect holds true.[129] One study showed that, in non-legal contexts, individuals were more likely to accept explanations of events that included neuroscientific language than those without.[130] While the experiment did not involve a legal setting, it presents a picture of how influential scientific and neuroscientific language can be over lay individuals, who can easily mistake scientific veneer for accepted fact.

Some data suggests that neuroimaging evidence might have undue influence in the courtroom.[131] Experiments found that realistic brain images, presented to a jury of laypeople, had the potential to influence opinion far beyond what the evidence warranted.[132] One study found that jurors were more likely to find a defendant "not guilty by reason of insanity" when presented with structural images of brain damage.[133] While this experiment concerned structural rather than functional neuroimaging, the results provide reason for caution relevant to any neuroimaging modality. Another study found that neu-

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125. *See* Teitcher, *supra* note 99, at 358; *see generally* Michael S. Pardo & Dennis Patterson, *Philosophical Foundations of Law and Neuroscience*, U. ILL. L. REV. 1211 (2010).

126. FED. R. EVID. 403.

127. *See, e.g.*, Brown & Murphy, *supra* note 24, at 1119.

128. *See* Judy Illes et al., *Neurotalk: Improving the Communication of Neuroscience Research*, 11 NATURE REVS. NEUROSCI. 61, 61 (2009).

129. *See, e.g.*, N.J. Schweitzer et al., *Neuroimages as Evidence in a Mens Rea Defense: No Impact*, 17 PSYCHOL. PUB. POL'Y & L. 357, 361 (2011).

130. Deena Skolnick Weisberg et al., *The Seductive Allure of Neuroscience Explanations*, 20 J. COGNITIVE NEUROSCI. 470, 476 (2008).

131. *Cf.* David P. McCabe & Alan D. Castel, *Seeing Is Believing: The Effect of Brain Images on Judgments of Scientific Reasoning*, 107 COGNITION 343, 343 (2008).

132. *See* Brown & Murphy, *supra* note 24, at 1189–90.

133. Jessica R. Gurley & David K. Marcus, *The Effects of Neuroimaging and Brain Injury on Insanity Defenses*, 26 BEHAV. SCI. L. 85, 93 (2008).

roscientific explanations were afforded more weight by a group of laypeople when they were accompanied by brain images.[134] Other studies, focusing on the effect of neuroimaging on mock juries, found potentially prejudicial effects, as neuroimaging evidence was considered more influential by the jury than verbal evidence alone.[135]

Conflicting results have emerged from recent meta-analyses[136] of the available data.[137] One large-scale study, which included a meta-analysis, explored the influence that neuroscience expert testimony and neuroimaging testimony had on mock juries when determining guilt in a criminal case.[138] They found that neuroimagery did not affect jurors' decisions to a greater extent than verbal neuroscience testimony.[139] The authors concluded that "the overwhelmingly consistent finding has been a lack of any impact of neuroimages on the decisions of our mock jurors."[140]

While these studies provide conflicting data, they clearly reveal the potentially prejudicial effects that neuroimaging and neuroscience-based evidence can have on juries. It is especially important to ensure that scientific information is understood by juries in the courtroom setting. Garrett and Neufeld, who studied the trial transcripts of 137 exonerated defendants, found that roughly 60% of those trials included science with basic methodological failures.[141] This study shows that misplaced faith in science can have devastating effects in the courtroom, and warns the courts to adopt a cautious approach.

Whether or not neuroimages are excluded for being unduly prejudicial also depends on how informative the neuroimages are, as highly prejudicial evidence can be admitted if it is extremely probative.[142] Unfortunately, given the limited data available, neuroimaging evidence is of limited probative value for many of its proposed uses in the courtroom, including as a method of lie detection. Scholars have pointed out that legal constructs do "not exist in the neuronal structures of the brain."[143] Even if fMRI was able to accurately associate brain function with activity in a specified brain region, it is unclear

134. *See* McCabe & Castel, *supra* note 131, at 346.

135. *See* Edith Greene & Brian S. Cahill, *Effects of Neuroimaging Evidence on Mock Juror Decision Making*, 30 BEHAV. SCI. L. REV. 280, 293 (2012); David P. McCabe et al., *The Influence of fMRI Lie Detection Evidence on Juror Decision-Making*, 29 BEHAV. SCI. & L. 566, 574 (2011).

136. A statistical technique for combining the findings from independent studies.

137. *See* Schweitzer et al., *supra* note 129, at 361.

138. *See id.*

139. *Id.* at 382.

140. *Id.*

141. Brandon L. Garrett & Peter J. Neufeld, *Invalid Forensic Science Testimony and Wrongful Convictions*, 95 VA. L. REV. 1, 2 (2009).

142. *See e.g.*, Edward J. Imwinkelried, *The Meaning of Probative Value and Prejudice in Federal Rule of Evidence 403: Can Rule 403 Be Used to Resurrect the Common Law of Evidence?*, 41 VAND. L. REV. 879, 889 (1988).

143. *See* MICHAEL S. GAZZANIGA, THE ETHICAL BRAIN 102 (2005).

that such findings would have the requisite probative value to gain evidentiary acceptance.[144]

V. fMRI Lie Detection Evidence Properly Excluded in Recent Cases

Despite evidentiary concerns, fMRI-based lie detection has found its way into U.S. courts. While only two cases have directly dealt with fMRI-based lie detection, evidentiary issues raised concerning the admissibility of fMRI lie detection studies in these cases provide a good barometer of courts' view of the current state of the art.

In 2010, a New York State trial judge excluded fMRI expert testimony about a witness's truthfulness in *Wilson v. Corestaff Services, L.P.*[145] This case involved an employment discrimination suit where the plaintiff submitted fMRI testimony to bolster the credibility of a witness by "proving" truthfulness.[146] The defense filed a motion in limine to exclude this testimony, which the trial court granted.[147] The court disallowed fMRI testimony because the proposed testimony concerned a collateral matter — the credibility of a witness — and because the court felt that the evidence would not meet the *Frye* standard regarding admissibility,[148] which demands that any novel scientific evidence be generally accepted in the field to which it belongs.[149] In rejecting the evidence, the judge correctly observed that the scientific community had not accepted fMRI lie detection as reliable.[150] As there was no appeal, the case has had little impact beyond its jurisdiction.

In *United States v. Semrau*, a federal court in Tennessee granted the government's motion to exclude fMRI expert testimony about the defendant's truthfulness.[151] In this case, Dr. Semrau was being charged with healthcare fraud and attempted to introduce fMRI lie detection evidence in order to prove the veracity of his denials of wrongdoing.[152] The court held an evidentiary hearing to determine whether fMRI lie detection evidence was sufficiently reliable to be

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144. *See* Stephen J. Morse, *Brain Overclaim Syndrome and Criminal Responsibility: A Diagnostic Note*, 3 OHIO ST. J. CRIM. L. REV. 397, 406 (2006) (arguing that neuroscience is unhelpful to the jury in determining legal criminal responsibility).

145. 900 N.Y.S.2d 639, 642 (Sup. Ct. 2010).

146. *See id.* at 640.

147. *Id.* at 640–42.

148. The *Frye* standard remains the dominant test in New York. *See* Giordano v. Market Am., Inc., 15 N.Y.3d 590, 601 (2010).

149. *Wilson*, 900 N.Y.S.2d at 642.

150. *Id.* ("[E]ven a cursory review of the scientific literature demonstrates that the plaintiff is unable to establish that the use of the fMRI test to determine truthfulness or deceit is accepted as reliable in the relevant scientific community.").

151. No. 07-10074 Ml/P, 2010 WL 6845092, at *1 (W.D. Tenn. June 1, 2010).

152. *Id.* at *2.

admitted.[153] The court invoked both FRE 702, which governs expert testimony, as well as the Supreme Court's *Daubert* factors, discussed above, in analyzing the admissibility of the offered fMRI lie detection results.[154]

The court found that while there was testability and that the data was published in peer-reviewed journals — which are considered the gold standard — fMRI lie detection fell short in the areas of identifiable error rates and maintenance of uniform testing standards.[155] The court focused on the lack of known error rates, expressing concern that the validity of fMRI lie detection in the real world, as opposed to laboratory context, was currently unknown.[156] The court pointed out that a critical flaw in current fMRI knowledge was the difference between the motivation of research participants and real world subjects to lie.[157] The judge also highlighted that while there were peer-reviewed studies, such studies had very small patient bases (all less than sixty participants), and included a range of participants who were not representative of the general population.[158] The court also pointed out that the use of neuroimaging for lie detection was still far from being generally accepted by the scientific community.[159] Both of these factors limited the applicability of the results to the general population and to *Semrau* in particular.

The court also noted that many of the reviewed studies involved investigators who were instructing participants to lie, which could lead to the possibility that the fMRI was detecting brain activity related to task compliance, rather than to deception.[160] The court held that based on the current state of the science, the "real life" error rate of fMRI-based lie detection was unknown, seriously hampering any chance of admissibility from a *Daubert* perspective.[161]

Interestingly, the court also held, pursuant to FRE 403, that any probative value related to fMRI would be outweighed by the potential for unfair prejudice by the jury.[162] The court analogized this to polygraph cases, pointing out that lie detection evidence has been found to be highly prejudicial and that neuroimaging, with its veneer of legitimate science, was likely to be even more so.[163] This potential for prejudice is even more important given the questionable probative

153. *Id.* at *1.
154. *Id.* at *9.
155. *Id.* at *10–12.
156. *Id.* at *11.
157. *Id.* at *11–12.
158. *Id.*
159. *Id.* at *13.
160. *Id.* at *12.
161. *Id.* at *13.
162. *See id.* at *13–16.
163. *Id.* at *11.

value of the evidence, due to the nascent science of the field, and other issues inherently related to the use of fMRI for lie detection.

The Sixth Circuit affirmed the District Court's opinion, and while we must be careful not to over-generalize findings from two cases, the analysis, especially in *Semrau* and its appeal, is likely to be carefully considered by other jurisdictions.[164] Indeed, the experts cited in *Semrau* are "considered well-qualified and authoritative," lending the opinion scientific and legal weight.[165] The affirmation by the Sixth Circuit, which in particular affirmed the exclusion of the evidence under both FRE 702 and 403, are major hurdles that any future defendant will have to overcome.

VI. How To Move Forward

Despite the growing enthusiasm for the introduction of fMRI determinations of truthfulness, the science simply is not advanced enough at this moment to support the desired legal application. However, we must not lose sight of the promise of this technique. Indeed, better evidence of truth-telling would allow juries and judges to make better decisions regarding credibility, especially given our current ineptitude at discerning truth from lies. This is especially important in criminal trials, where fundamental liberties are most at risk and determinations of credibility carry significant weight. Given its potential, there are a number of practical steps that could begin to address the current shortcomings of fMRI lie detection technology.

Further experimental investigation is essential to moving the field forward. Larger studies are needed to ensure that the results have robust statistical power. This will require investment in large-scale trials involving well-maintained fMRI machines — an expensive proposition, but one with significant scientific promise. Further research will also be needed to address the current unknowns surrounding BOLD response and countermeasures.

The investment in large-scale studies will allow researchers to generate better data concerning "normal" brain function. Such data is essential, particularly from a legal perspective, as jurisprudence is concerned with deviations from the norm. More normative data is the first step toward allowing researchers to begin to establish baselines and patterns that will enable valid comparisons of fMRI results. Such comparisons must be based on robust data rather than on comparisons to small groups of potentially non-representative control subjects. Increased data will also enable researchers to account for expected variations between individual brain activation patterns and differences

164. *See* United States v. Semrau, 693 F.3d 510 (6th Cir. 2012).
165. *See* Langleben & Moriarty, *supra* note 11, at 9.

that may be related to group variability (e.g., by handedness or age). There must also be continued investment in improving fMRI scanners to enable more clear and accurate images of cerebral blood flow.

Improvements in standardization, understanding, and accuracy will allow neuroimaging modalities to more reliably survive *Daubert*-style challenges to their validity. Increased acceptance and validity will increase the probative value of fMRI evidence, helping such evidence to survive FRE 403 challenges. This makes it essential for legal scholars to work with medical researchers, so that specific legal concerns can be addressed through further experimentation. With improvements in technology, interpretation, and experimental design, data will hopefully emerge that will address many of the concerns currently keeping fMRI from the courtroom. Until such a time, the current state of fMRI lie detection mandates that we advocate caution rather than immediate adoption of this technology into criminal jurisprudence.