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Weighing the Admissibility of fMRI Technology Under FRE 403: For the Law, fMRI Changes Everything -- and Nothing

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WEIGHING THE ADMISSIBILITY OF fMRI TECHNOLOGY UNDER FRE 403: FOR THE LAW, fMRI CHANGES EVERYTHING—AND NOTHING[†]

*Justin Amirian**

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[†] This title is a play on the title of an influential neuroscience article. See Joshua Greene & Jonathan Cohen, *For the Law, Neuroscience Changes Everything and Nothing*, 359 PHIL. TRANSACTIONS ROYAL SOC’Y. B BIOLOGICAL SCI. 1775 (2004).

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INTRODUCTION

Assuming that society and the justice system possess an inherent interest in truth,¹ what social benefit justifies what would arguably be the most intimate invasion of privacy possible?² What is the role of the jury, and what purpose does it serve within the larger confines of our justice system?³ Is it possible to utilize lie detection technology without displacing the jury's role and purpose?⁴

What does it mean for evidence to be reliable? How reliable must evidence be before we allow it to be considered by the jury? Would that level of reliability be different if the evidence was only shown to a judge? Does the requisite level of reliability differ for different kinds of evidence?⁵ In determining reliability, why must a judge use scientific norms to assess legal relevance?⁶ If lie detection becomes sufficiently reliable under legal standards, will it be admissible in court?

These are but a few of the questions that the advent of deception detection using functional magnetic resonance imaging (fMRI) has raised. This Note only purports to definitively answer the last of these questions: whether lie detection, if it becomes sufficiently reliable under legal standards, will be admissible in court, while shedding light on at least some of the others. As an established scholar in the field of neuroimaging recently pointed out, the comparisons of this technology to the mind-reading lore of *1984*, *Minority Report*, and *Inception* are premature, generating debates that are "too untethered from scientific reality."⁷ This technology,

1. Charles N.W. Keckler, *Cross-Examining the Brain: A Legal Analysis of Neural Imaging for Credibility Impeachment*, 57 HASTINGS L.J. 509, 553–54 (2006). Keckler assumes that "society possesses an interest in the truth, and that the Anglo-American adversary system purports to serve this interest." *Id.* But the admissibility of fMRI deception detection technology must be contemplated in a vacuum because the economic litigation approach, under which "litigation is preferred over settlement only so long as the parties have different expectations of trial outcome," may in fact perpetuate confusion. *Id.*

2. See Brian Reese, *Using fMRI as a Lie Detector—Are We Lying to Ourselves?*, 19 ALB. L.J. SCI. & TECH. 205, 205 (2009).

3. See Julie A. Seaman, *Black Boxes*, 58 EMORY L. J. 427, 434 (2008).

4. See Aaron M. Stronge, *Absolute Truth or Deus Ex Machina?: The Legal and Philosophical Ramifications of Guilt-Assessment Technology*, 10 J. HIGH TECH. L. 113 (2009).

5. See generally Frederick Schauer & Barbara A. Spellman, *Is Expert Evidence Really Different?* 9 (Feb. 1, 2013) (unpublished manuscript), available at <http://ssrn.com/abstract=2210397>.

6. See *id.*

7. Francis X. Shen, *Neuroscience, Mental Privacy, and the Law*, 36 HARV. J.L. & PUB. POL'Y 653, 655 (2013).

however, is more likely than any others that have come before it to reliably distinguish a person's truthful statements from deceptive ones.⁸

Part I of this Note provides an overview of the anatomy of a lie and the technologies used to detect them. Part II discusses the relevant evidentiary rules governing the admissibility of such technology, as well as the evidentiary significance of these technologies under these rules. Part III considers the admissibility of fMRI deception detection technology once it becomes reliable enough to satisfy the standards governing scientific expert testimony. Part IV concludes the discussion, finding that this technology's probative value will not be outweighed by any potential for undue prejudice, or to confuse or mislead the jury.

I. BACKGROUND

A. Lie Detection

Humans have sought the ability to distinguish the truth from a lie from time immemorial. Lies take many different forms, and different techniques and technologies have been developed to try to measure these different lies. The most famous lie detection technology is the polygraph, but new technology that measures the brain's activity now offers the greatest potential to be of use for the legal system.

1. Executive Function

Evolution has endowed humans with several capabilities that separate us from our animal kin. Of these, perhaps the most important is the growth of a part of our brains called the prefrontal cortex, which has grown at a faster rate in *homo sapiens* than in the rest of the animal kingdom.⁹ The prefrontal cortex is the crux of what separates humans from our evolutionary brethren,¹⁰ allowing us to engage in a broad range of behaviors encapsulated by the term

8. Daniel D. Langleben & Jane Campbell Moriarty, *Using Brain Imaging for Lie Detection: Where Science, Law, and Policy Collide*, 19 PSYCHOL. PUB. POL'Y & L. 222, 223 (2013) (asserting that fMRI will be more successful in detecting lies than electroencephalography and polygraph technology).

9. See Katerina Semendeferi et al., *Prefrontal Cortex in Humans and Apes: A Comparative Study of Area 10*, 114 AM. J. PHYSICAL ANTHROPOLOGY 224, 224 (2001).

10. See Kate Teffer & Katerina Semendeferi, *Human Prefrontal Cortex: Evolution, Development, and Pathology*, in 195 PROGRESS IN BRAIN RESEARCH 191, 191 (Michael A. Hoffman & Dean Falk eds., 2012).

“executive function.”¹¹ These behaviors include problem-solving, modifications in behavioral responses to stimuli, planning, and behavioral inhibition—allowing humans to conform to society’s expectations.¹² Although deception predates the evolution of language,¹³ the evolutionary growth of the brain’s prefrontal cortex, and consequential advent of language, led to an “efflorescence of [deception] complexity.”¹⁴ This executive function system works in conjunction with other parts of the brain, such as those that deal with instincts like breathing and sleeping.¹⁵ Crucially, for the purposes of this Note, the executive function interacts with the parts of the brain that deal with memory.¹⁶

2. *Anatomy of a Lie*

Truth is not a binary concept—it lies on a wide spectrum.¹⁷ There are theoretically three types of lies.¹⁸ First, when a subject, who knows of some fact X, is asked if he knows of X, and he feigns

11. Sean A. Spence et al., *A Cognitive Neurobiological Account of Deception: Evidence from Functional Neuroimaging*, 359 PHIL. TRANSACTIONS ROYAL SOC’Y. B BIOLOGICAL SCI. 1755, 1755–56 (2004).

12. See Archie Alexander, *Functional Magnetic Resonance Imaging Lie Detection: Is A “Brainstorm” Heading Toward the “Gatekeeper”?*, 7 HOUS. J. HEALTH L. & POL’Y 1, 9–10 (2006).

13. See Keckler, *supra* note 1, at 519 (citing Robin Dunbar, *On the Origin of the Human Mind*, in *EVOLUTION AND THE HUMAN MIND: MODULARITY, LANGUAGE, AND META-COGNITION* 238–53 (Peter Carruthers & Andrew Chamberlain eds., 2000)).

14. *Id.* at 519 n.36 (“In human evolution, processes of deception and self-deception were greatly heightened by the advent of language. Language permits individuals to make statements about events distant in time and space, and these are least amenable to contradiction. Thus, language permits verbal deception of many different kinds.” (quoting ROBERT TRIVERS, *SOCIAL EVOLUTION* 416 (1985))).

15. See Semendeferi et al., *supra* note 9, at 193.

16. See Maria Jurado & Monica Rosselli, *The Elusive Nature of Executive Functions: A Review of our Current Understanding*, 17 NEUROPSYCHOLOGY REV. 213, 215 (2007).

17. See Alexander, *supra* note 12, at 12–13 (describing the spectrum of conveying information from intentional to unintentional distortions of truth, including “concealment, distortion, fabrication, or manipulation of truthful information”); see also Keckler, *supra* note 1, at 539 (citing Bella M. DePaolo et al., *Cues to Deception*, 129 PSYCHOL. BULL. 74, 105 (2003)) (referring to a meta-analysis of 1338 cues of deception, which indicates a large psychological gray area between truth and deceit); Jed S. Rakoff, *Lie Detection in the Courts: The Vain Search for the Magic Bullet*, in *USING IMAGING TO IDENTIFY DECEIT: SCIENTIFIC AND ETHICAL QUESTIONS* 40, 44 (2009) (“The law recognizes many kinds of lies, ranging from ‘white lies’ and ‘puffing’ to affirmative misstatements, actionable half-truths, and material omissions.”).

18. These categories are the author’s own variation of several mentioned throughout the literature. See, e.g., Keckler, *supra* note 1, at 510.

ignorance of this fact, that is called “guilty knowledge.”¹⁹ The second category is when a subject makes a genuine assertion of truth that is not objectively true—these assertions are sometimes “mistakes” or “delusions.”²⁰ The third, and possibly most important, category is when a subject knows of some fact X, yet when asked if he has any knowledge of X, he instead responds with some falsehood Y.²¹ The key difference between the latter two categories is the *intent* of the subject to deceive in the third category, as compared with the honest assertion of subjective truth in the second.²² In this third category, the subject must suppress truth X from his memory, while simultaneously constructing falsehood Y.²³

3. Deception Detection Techniques

The first of two techniques commonly used to detect deception is the Control Question Test (CQT).²⁴ This test theoretically allows an examiner to detect deception by comparing a subject’s physical responses to different types of questions.²⁵ An examiner usually asks an innocuous “control question,” such as the subject’s name, to get a baseline reading of the subject’s physical response while being honest and truthful.²⁶ Then the examiner asks pointed and relevant questions, which have to do with the topic of the test.²⁷ Deception is inferred when physical reactions are stronger or different in the “relevant” condition than in the “control” condition.²⁸

Another commonly used method to detect deception is the Guilty Knowledge Test (GKT),²⁹ which is also referred to as the Concealed Information Test (CIT).³⁰ This test can theoretically determine if a subject has intimate knowledge about the details of a question, such

19. *See id.*

20. Eric K. Gerard, *Waiting in the Wings? The Admissibility of Neuroimaging for Lie Detection*, 27 DEV. MENTAL HEALTH L. 1, 7 (2008).

21. *See* Keckler, *supra* note 1, at 510.

22. *See* Gerard, *supra* note 20.

23. Michael S. Pardo, *Neuroscience Evidence, Legal Culture, and Criminal Procedure*, 33 AM. J. CRIM. L. 301, 312–13 (2006).

24. *See* John B. Meixner, *Liar, Liar, Jury’s the Trier? The Future of Neuroscience-Based Credibility Assessment in the Court*, 106 NW. U. L. REV. 1451, 1455 (2012).

25. *See id.*

26. *See id.* at 1455–56.

27. *See id.* at 1455.

28. *See id.* at 1456.

29. *See id.* at 1458 n.42.

30. *See id.*

as the specific details of a crime or weapon used.³¹ Similar to the CQT, an examiner uses the GKT to derive his conclusions from the elevated physical response that a subject theoretically shows when asked about, or shown, details of a crime.³² The GKT's distinguishing factor is that it does not attempt to discern if a person is lying per se; rather, it is only used to discern whether a person has relevant knowledge of details of a crime that, most likely, only the perpetrator would know.³³ If the subject has denied knowledge of these details, yet the test shows physical arousal, the examiner may infer deception.³⁴

B. Lie Detection Technology

The polygraph changed the landscape of lie detection in the modern age, but newer technologies that measure activity in the brain have the potential to alter this landscape even more significantly.³⁵

1. Polygraph

Polygraph technology measures a subject's physiological reactions to questions given by an examiner.³⁶ Corrugated rubber tubes or electronic sensors measure respiratory activity,³⁷ cardiographs measure heart rates,³⁸ and galvanic skin electrodes measure perspiration.³⁹ The premise of the polygraph test is that a subject will exhibit a different physiological reaction when lying than when telling the truth.⁴⁰

Several problems plague both the technology and its use. First, the examiner's behavior can have a strong influence on the subject and

31. *See id.* at 1458.

32. *See id.*

33. *See id.* at 1459.

34. *See id.* at 1458 (providing that in such circumstances knowledge of the crime may be inferred).

35. *See* Leo Kittay, *Admissibility of fMRI Lie Detection: The Cultural Bias Against "Mind Reading" Devices*, 72 *BROOK. L. REV.* 1351, 1360–61 (2007).

36. *See Frequently Asked Questions*, AM. POLYGRAPH ASS'N, <http://www.polygraph.org/section/resources/frequently-asked-questions> (last visited Nov. 22, 2013).

37. *Id.*

38. Gerard, *supra* note 20, at 20 (citing Steven I. Friedland, *Law, Science, and Malingering*, 30 *ARIZ. ST. L.J.* 337, 357 (1998)).

39. *Id.*

40. *See id.*

his responses.⁴¹ Second, the examiner must subjectively interpret the results to conclude that the subject was being deceptive, allowing for elements of human error.⁴² Third, the physiological reactions that this technology measures are not unique to deception;⁴³ instead of detecting deception, the technology could be reading reactions caused by anxiety from the test or its possible consequences.⁴⁴ Fourth, polygraph tests are notoriously vulnerable to countermeasures that allow subjects to avoid deception detection.⁴⁵ Finally, reported accuracy rates have a very large range, anywhere from the “toss of a coin”⁴⁶ to ninety percent in controlled settings.⁴⁷

2. Brain Imaging

Examiners have utilized technology that measures brain activity to measure lie detection. Older and less precise technologies have given way in scientific and legal realms to the fMRI.

a. Lesser Used Technologies

Several functional neuroimaging techniques predate the fMRI technique that is the focus of this Note. Positron Emission Tomography (PET) and Single Photon Emission Computed

41. See Spencer J. Brooks, *Scanning the Horizon: The Past, Present, and Future of Neuroimaging for Lie Detection in Court*, 51 U. LOUISVILLE L. REV. 353, 360 (2013) (asserting that the expectations of the test-giver can influence both his interpretation and the subject’s responses); see also Gerard, *supra* note 20, at 21 (asserting that an examiner’s tone of voice, posture, comportment, intonation, and other verbal and non-verbal cues may all affect subject responses); Kittay, *supra* note 35, at 1362.

42. See Gerard, *supra* note 20, at 21 (“[E]xaminers may differ in the numerical values they assign for a set of answers and their attendant physiological responses.”).

43. Brooks, *supra* note 41, at 359.

44. Gerard, *supra* note 20, at 21.

45. Kittay, *supra* note 35, at 1364 (“Subjects have used counter-measures, such as sedatives, to dampen their autonomic responses and stressors, such as flexing muscle or placing tacks in a shoe, to artificially inflate or create stress reactions.”); see also Alexander, *supra* note 12, at 31 (stating that subjects may engage in “the self infliction of pain[] to create a false physiological response to the control questions.”); Brooks, *supra* note 41, at 359; Gerard, *supra* note 20, at 21.

46. *United States v. Cordoba*, 991 F. Supp. 1199, 1203 (C.D. Cal. 1998), *aff’d*, 194 F.3d 1053 (9th Cir. 1999) (quoting W. Iacono & D. Lykken, *The Scientific Status of Research on Polygraph Techniques: The Case Against Polygraph Tests*, in 1 MODERN SCIENTIFIC EVIDENCE § 14-3 (D. Faigman et al. eds., 1997)).

47. Kittay, *supra* note 35, at 1363 (citing 4 MODERN SCIENTIFIC EVIDENCE §§ 40:25–28 (D. Faigman et al. eds., 2005–06)). The American Polygraph Association claims accuracy in the range of eighty-five to eighty-nine percent. *Polygraph Validity Research*, AM. POLYGRAPH ASS’N, www.polygraph.org/section/resources/polygraph-validity-research (last visited Nov. 22, 2013).

Tomography (SPECT) both detect the emission of gamma rays emitted from a radioactive tracer that is injected into a subject's bloodstream.⁴⁸ Both of these methods share common methodologies with fMRI as to how the resulting image is constructed from the raw data.⁴⁹

Electroencephalography (EEG) measures the brain's electrical activity via electrodes placed on a scalp.⁵⁰ Some scientists claim to be able to utilize EEG to detect experiential knowledge (or "guilty knowledge") of a an event or stimulus, called "brain fingerprinting."⁵¹ Scientists measure electrical currents after giving the subject a stimulus,⁵² which is composed of some "relevant knowledge of the salient features or events associated with a crime."⁵³ These scientists claim that, after being shown relevant knowledge related to the crime, subjects with "guilty knowledge" in their memory emit an electrical response 300 milliseconds later—dubbed the "P300 wave."⁵⁴

b. Functional Magnetic Resonance Imaging (fMRI)

Scholars have touted fMRI as the most promising technology for purposes of legal lie detection⁵⁵ because of its increased availability, reduction in cost,⁵⁶ and optimal balance in resolution.⁵⁷ This technique utilizes the "technology of regular magnetic resonance

48. 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, 1136 (2010).

49. *Id.*

50. *Id.*

51. See Alexander, *supra* note 12, at 35–40.

52. Henry T. Greely & Judy Illes, *Neuroscience-Based Lie Detection: The Urgent Need for Regulation*, 33 AM. J.L. & MED. 377, 387 (2007).

53. Alexander, *supra* note 12, at 36.

54. See *id.* For a discussion of cases that have discussed the admissibility of this technology, see *id.* at 36–40.

55. There is a great deal of publication on the science behind fMRI technology, with varying degrees of detail. For in-depth discussion on fMRI, its various measurements, and the resulting inferences that can be made, see Brown & Murphy, *supra* note 48, at 1138–55. For detailed discussion on the physics and minutiae of fMRI, see Alexander, *supra* note 12, at 15–24 (explaining fMRI technology from the atomic level upward). For in-depth explanation of broader neuroscience concepts and technologies, see generally HENRY T. GREELY & ANTHONY D. WAGNER, REFERENCE MANUAL ON SCIENTIFIC EVIDENCE: REFERENCE GUIDE ON NEUROSCIENCE (3d ed. 2011). For further background, see Mark Pettit, Jr., *fMRI and BF Meet FRE: Brain Imaging and the Federal Rules of Evidence*, 33 AM. J.L. & MED. 319, 340 (2007); Reese, *supra* note 2, at 227.

56. See Brown & Murphy, *supra* note 48, at 1138.

57. See ORRIN DEVINSKY & MARK D'ESPOSITO, NEUROLOGY OF COGNITIVE AND BEHAVIORAL DISORDERS 57 (2004).

imaging adapted to detect changes in hemodynamic (literally ‘blood movement’) properties of the brain occurring when the subject is engaged in very specific mental tasks.”⁵⁸ fMRI is an upgrade over other types of neuroimaging technologies because it is quick, safe, and non-invasive.⁵⁹ fMRI creates a primary magnetic field and one in each three-dimensional plane within the confines of the machine.⁶⁰ While in the apparatus, the atoms in the subject’s brain align in accordance with this magnetic field.⁶¹ The subject then engages in mental tasks while the machine measures magnetic activity in three-dimensional, cubic volumes of brain tissue called “voxels.”⁶² The machine records this activity in many different dimensions, or “slices,” of the brain for its spatial resolution, as well as over the span of several seconds for temporal resolution.⁶³ Scholars believe that fMRI has the best balance in the necessary trade-offs between spatial and temporal resolution.⁶⁴

fMRI technology indirectly monitors brain activity through the measurement of differences in the magnetic properties of blood over time, called Blood Oxygen Level Dependent (BOLD) response.⁶⁵ It is important to emphasize that fMRI does not directly measure the movement or firing of neurons.⁶⁶ All mental activity, however, does require neuronal firing—the more complex the mental task, the more neurons are recruited to fire, as well as more often.⁶⁷ Since the brain does not contain reserves for energy, neuronal access to oxygen must constantly be refreshed.⁶⁸ The oxygenated blood carrying energy to

58. Owen D. Jones et al., *Brain Imaging for Legal Thinkers: A Guide for the Perplexed*, 2009 STAN. TECH. L. REV. 5, 16.

59. Brown & Murphy, *supra* note 48, at 1138. For example, even though EEG is less expensive and more mobile, fMRI is vastly superior in its ability to localize the sources of signals in the brain. Langleben & Moriarty, *supra* note 8. For a discussion of the actual experience of an fMRI scan, see Brown & Murphy, *supra* note 48, at 1139.

60. *See* Jones et al., *supra* note 58, at 18.

61. *See id.*

62. *See id.* at 17.

63. *See id.*; *see also* Greely & Illes, *supra* note 52, at 381–82 (discussing the differences and trade-offs between spatial and temporal resolution).

64. DEVINSKY & D’ESPOSITO, *supra* note 57, at 57.

65. *See* Brown & Murphy, *supra* note 48, at 1138. For further discussion of what is known and the uncertainties of BOLD, *see id.* at 1139–42. For a discussion of variability in blood flow, *see* Greely & Illes, *supra* note 52, at 380–81.

66. *See* Brown & Murphy, *supra* note 48, at 1138; *see also* Greely & Illes, *supra* note 52, at 380.

67. *See* Brown & Murphy, *supra* note 48, at 1138.

68. *Id.* The brain derives energy through the oxidation of glucose to create adenosine triphosphate (ATP). Greely & Illes, *supra* note 52, at 380.

these neurons is magnetically discernible from deoxygenated blood particles that have already delivered oxygen to neurons.⁶⁹ fMRI scan images depict the BOLD responses over time and through space—it is not a picture or snapshot of the brain at any given time.⁷⁰

fMRI imaging helps researchers determine which parts of the brain are involved in performing cognitive tasks by utilizing the theory of cognitive subtraction.⁷¹ “Part of the art of fMRI imaging is designing an experimental task that is simple and specific so that behavioral responses can be attributed to an isolated mental process and not confounded by other functions”⁷² Researchers employ the difference between the control and experimental tasks’ BOLD responses in making deductions about which pathways were used to accomplish the tasks in each condition.⁷³

Researchers have applied fMRI technology and the cognitive subtraction theory in an attempt to locate the neural mechanisms recruited for deception, with some studies confirming either the possibility of, or actual, experimental success in distinguishing lies from truth telling.⁷⁴ There is currently no overwhelming consensus on

69. Brown & Murphy, *supra* note 48, at 1138.

70. Adina L. Roskies, *Are Neuroimages Like Photographs of the Brain?*, 74 PHIL. SCI. 860–72 (2007).

71. Greely & Illes, *supra* note 52, at 383; Sean A. Spence, *Playing Devil’s Advocate: The Case Against fMRI Lie Detection*, 13 L. & CRIMINOLOGICAL PSYCHOL. 11, 12–13 (2008) (explaining the role of cognitive subtraction in fMRI research).

72. Greely & Illes, *supra* note 52, at 383.

73. *Id.*

74. Frederick Schauer, *Can Bad Science Be Good Evidence? Neuroscience, Lie Detection, and Beyond*, 95 CORNELL L. REV. 1191, 1197 n.31 (2010) (compiling the sources of many studies researching fMRI detection of deception); *see, e.g.*, Christos Davatzikos et al., *Classifying Spatial Patterns of Brain Activity with Machine Learning Methods: Application to Lie Detection*, 28 NEUROIMAGE 663, 668 (2005) (concluding that a nonlinear pattern classification method can detect patterns of brain activity associated with lying); G. Ganis et al., *Neural Correlates of Different Types of Deception: An fMRI Investigation*, 13 CEREBRAL CORTEX 830, 832–38 (2003) (yielding results that “show that different patterns of brain activation arise when people tell lies than when they tell the truth”); Joshua D. Greene & Joseph M. Paxton, *Patterns of Neural Activity Associated with Honest and Dishonest Moral Decisions*, 106 PROC. NAT’L ACAD. SCI. U.S. 12506, 12509–10 (2009) (suggesting that individual differences in brain “control network activity” are associated with differences in presence of dishonest behavior); F. Andrew Kozel et al., *Brief Communication: A Replication Study of the Neural Correlates of Deception*, 118 BEHAV. NEUROSCIENCE 852, 855 (2004) (finding that “[f]or lying, compared with telling the truth, there is more activation in the right anterior cingulate, right inferior frontal, right orbitofrontal, right middle frontal, and left middle temporal areas”); F. Andrew Kozel et al., *Detecting Deception Using Functional Magnetic Resonance Imaging*, 58 BIOLOGICAL PSYCHIATRY 605, 611 (2005) [hereinafter Kozel et al.,

which neural regions are consistently recruited for deception.⁷⁵ Nevertheless, that may be because different experiments engender the assertion of different kinds of lies. These different types of lies, in turn, would engage different types of cognitive processes and

Detecting Deception] (concluding that “fMRI can be used to detect deception within a cooperative individual”); 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 NEUROSCIENCE 295, 304 (2004) [hereinafter Kozel et al., *Pilot Study*] (concluding that using blood oxygen level dependent fMRI “to investigate brain changes associated with deception is . . . possible”); Daniel D. Langleben et al., *Telling Truth from Lie in Individual Subjects with Fast Event-Related fMRI*, 26 HUM. BRAIN MAPPING 262, 271 (2005) [hereinafter Langleben et al., *Telling Truth*] (concluding that fMRI images may be able to distinguish a truth from a lie on the basis that a lie “appears to be a more working memory-intensive activity, characterized by increased activation of the inferolateral cortex implicated in response selection, inhibition, and generation”); Daniel D. Langleben et al., *Rapid Communication, Brain Activity During Simulated Deception: An Event-Related Functional Magnetic Resonance Study*, 15 NEUROIMAGE 727, 731 (2002) (finding a “neurophysiological difference between deception and truth”); Tatia M.C. Lee et al., *Neural Correlates of Feigned Memory Impairment*, 28 NEUROIMAGE 305, 310–12 (2005); Tatia M.C. Lee et al., *Lie Detection by Functional Magnetic Resonance Imaging*, 15 HUM. BRAIN MAPPING 157, 163 (2002) (concluding that it is “unfeasible” to control one’s cerebral activity to avoid lie detection); Donald H. Marks et al., *Determination of Truth From Deception Using Functional MRI and Cognitive Engrams*, 5 INTERNET J. RADIOLOGY 1 (2006), available at <http://ispub.com/IJRA/5/1/9241> (showing that “specific activation patterns occur in the brain of individuals looking at specific pictures, and also whether they are contemplating giving a truthful or a deceptive response”); 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) (concluding that “specific areas of the brain involved in deception or truth telling can be depicted with functional MR imaging”); Jennifer Maria Nuñez et al., *Intentional False Responding Shares Neural Substrates with Response Conflict and Cognitive Control*, 25 NEUROIMAGE 267, 273–76 (2005) (finding certain brain regions to be “significantly more active when falsifying information as compared to when answering truthfully”); Sean A. Spence et al., *Speaking of Secrets and Lies: The Contribution of Ventrolateral Prefrontal Cortex to Vocal Deception*, 40 NEUROIMAGE 1411, 1415–18 (2008) [hereinafter Spence et al., *Speaking of Secrets*]; Sean A. Spence et al., *Behavioural and Functional Anatomical Correlates of Deception in Humans*, 12 NEUROREPORT 2849, 2851–52 (2001) (finding that individuals telling lies have increased response times and increased activation in specific regions of the brain).

75. Compare Langleben et al., *Telling Truth*, *supra* note 74, at 271 (asserting that the inferolateral cortex, which is responsible for response selection, inhibition, and generation, is largely implicated in deception), with Jonathan G. Hakun et al., *Towards Clinical Trials of Lie Detection with fMRI*, 4 SOC. NEUROSCIENCE 518 (2009) (hypothesizing that the prefrontal-parietal system, which is responsible for behavioral control and attention, is the locus of deception). Although there is no overwhelming consensus, the regions that have resulted in the most consistent activation are the prefrontal cortex, anterior cingulate cortex, and parietal cortex. See Martha J. Farah et al., *Functional MRI-Based Lie Detection: Scientific and Societal Challenges*, 15 NATURE REVIEWS NEUROSCIENCE 123, 123 (2014).

different parts of the brain.⁷⁶ Subjects are first scanned during a baseline task of telling the truth.⁷⁷ Next, the subjects are scanned while engaged in an experiment that leads them to lie. Finally, the areas engaged in the former condition are subtracted from those in the latter, theoretically leaving researchers with the areas unique to deception.⁷⁸

Several unifying themes exist among the available scientific research. First, some form of “executive” function is implicated in choosing to respond with truth or deception,⁷⁹ most often within the brain’s prefrontal cortex.⁸⁰ Second, deception usually recruits an area within the brain correlated with memory.⁸¹ Third, deception usually requires more brain activity and more time.⁸² Finally, this technology can only test a subject’s subjective *belief* in the truth or falsity of his statements⁸³: indeed, fMRI imaging currently cannot discern honest yet mistaken beliefs,⁸⁴ or delusions.⁸⁵

As with any nascent science, fMRI imaging is generally improving. The hardware itself, as well as the algorithms and software that utilize the resulting raw data, are improving the technology’s accuracy and reliability.⁸⁶ Ultimately, fMRI’s ability to accurately measure and

76. Pardo, *supra* note 23, at 313 (2006) (citing Giorgio Ganis et al., *Neural Correlates of Different Types of Deception: An fMRI Investigation*, 13 *CEREBRAL CORTEX* 830, 831 (2003)) (“For example, spontaneous isolated lies may require different cognitive processes than memorized lies forming a coherent scenario.”).

77. Brown & Murphy, *supra* note 48, at 1136 n.63 (2010).

78. Spence, *supra* note 71, at 12–13 (explaining the role of cognitive subtraction in fMRI research).

79. Alexander, *supra* note 12, at 11–12 (2006) (compiling the results of all known fMRI deception detection experiments through 2006); Keckler, *supra* note 1, at 535 (analyzing the results of several major, widely-cited fMRI lie detection studies through 2005).

80. Spence, *supra* note 71, at 22.

81. Keckler, *supra* note 1, at 535, 539–40 (asserting that one must hold the truth in working memory while constructing a lie in order to be able to compare the two for a response).

82. Spence, *supra* note 71, at 22.

83. Frederick Schauer, Lie-Detection, Neuroscience, and the Law of Evidence 17 n.36 (Oct. 22, 2012) (unpublished manuscript), *available at* <http://ssrn.com/abstract=2165391>.

84. Seaman, *supra* note 3, at 475 (citing Helen Pearson, *Lure of Lie Detectors Spooks Ethicists*, 441 *NATURE* 918, 919 (2006)) (“[D]ata collected from healthy subjects reveal little about the mindset of someone who genuinely believes they are telling the truth or someone who is confused, delusional or a pathological liar.”).

85. *Id.* (citing Sean Spence et al., ‘*Munchausen’s Syndrome by Proxy*’ or a ‘*Miscarriage of Justice*’? An Initial Application of Functional Neuroimaging to the Question of Guilt Versus Innocence, 23 *EUR. PSYCHOL.* 309, 311–13 (2008)).

86. See generally Julie Elizabeth Myers, *The Moment of Truth for fMRI: Will Deception Detection Pass Admissibility Hurdles in Oklahoma?*, 6 *OKLA. J. L. &*

localize cognitive activity has created the expectation that it will be, if it is not already, the most successful lie detection technology yet.⁸⁷

fMRI already enjoys several distinct technological advantages over the polygraph. Most importantly, fMRI is a first-order measurement,⁸⁸ directly measuring the central correlate of the nervous system. In other words, fMRI measures the brain activity at its source, which gives rise to the galvanic skin response, heart rate, blood pressure, respiration changes that the polygraph measures.⁸⁹ Secondly, and as a corollary to the previous point, fMRI is theoretically less susceptible to countermeasures,⁹⁰ as well as confounding influences.⁹¹ One scholar analogizes a subject's complex neurological pattern of deception to a fingerprint: confounding influences, such as stress or anxiety, would create distinct patterns that are distinguishable from a pattern produced by deception, and thus would be less likely to produce false positives.⁹² Third, fMRI's increased computerization⁹³ allows for more accurate and objective results.⁹⁴ Fourth, fMRI obtains data that cannot be acquired through

TECH. 47 (2010); *see also*, J.R.H. Law, *Cherry-Picking Memories: Why Neuroimaging-Based Lie Detection Requires a New Framework for the Admissibility of Scientific Evidence Under FRE 702 and Daubert*, 14 YALE J. L. & TECH. 1, 39 (2011) ("Some of the newest techniques for controlling false positives have only been developed in the last few years.").

87. Langleben & Moriarty, *supra* note 8, at 223 (asserting that fMRI will be more successful in detecting lies than EEG and polygraph technology).

88. Seaman, *supra* note 3, at 446.

89. Langleben & Moriarty, *supra* note 8, at 223.

90. Gerard, *supra* note 20, at 26 (2008) ("Control over blood flow within one's brain is more difficult to accomplish than control over physiological responses such as one's heart or respiratory rate."). *But see* Giorgio Ganis et al., *Lying in the Scanner: Covert Countermeasures Disrupt Deception Detection by Functional Magnetic Resonance Imaging*, 55 NEUROIMAGE 312, 317–18 (2011) (asserting that subjects can be trained to avoid deception detection). Indeed, one scholar points out that due to the sensitivity of fMRI measurement, most small movements such as moving one's head, fingers or tongue, or even doing mental arithmetic, could confound an experiment's results. *See* Nancy Kanwisher, *The Use of fMRI in Lie Detection: What Has Been Shown and What Has Not*, in USING IMAGING TO IDENTIFY DECEIT: SCIENTIFIC AND ETHICAL QUESTIONS, *supra* note 17, at 7, 12.

91. Keckler, *supra* note 1, at 540 (stating the anxiety would create another distinct brain activity pattern, not create a pattern that would be confused with deception).

92. *Id.*

93. Neal Feigenson, *Brain Imaging and Courtroom Evidence: On the Admissibility and Persuasiveness of fMRI*, 2 INT'L J. L. CONTEXT 247 (2006) (discussing the objective and "mathematised" nature of fMRI data); Gerard, *supra* note 20, at 26 (2008).

94. Kittay, *supra* note 35, at 1365 (2007); Myers, *supra* note 86, at 13 (asserting that the computerization aspect puts fMRI in a different class of evidence than polygraphs, fingerprinting, and even Deoxyribonucleic acid (DNA) sequencing).

normal social interaction,⁹⁵ and its results do not require subjective interpretation.⁹⁶

As it currently stands, a majority of both legal⁹⁷ and scientific⁹⁸ articles contend that fMRI technology is in need of much improvement before its legal admissibility should be seriously considered.⁹⁹ The application of this technology for lie detection purposes is also fraught with constitutional issues that must be addressed before its widespread adoption for criminal prosecution.¹⁰⁰ Besides technical improvements, fMRI must increase its reproducibility and reliability at several different levels: imaging must be conducted when the stakes are higher, on more diverse subjects, with testing on the individual level, and with subjects employing

95. Kittay, *supra* note 35, at 1389 (2007) (“No matter how closely a jury pays attention, it would not be able to determine which brain region the defendant used to answer a question.”).

96. Brown & Murphy, *supra* note 48, at 1189. However, fMRI does require scientists to set thresholds in the acquisition of results, which some analogize to interpretation. *Id.*

97. *See, e.g.*, Charles Adelsheim, *Functional Magnetic Resonance Detection of Deception: Great as Fundamental Research, Inadequate as Substantive Evidence*, 62 *MERCER L. REV.* 885 (2011); Brown & Murphy, *supra* note 48, at 1189; Law, *supra* note 86, at 1.

98. *See* Schauer, *supra* note 74, at 1200 n.46 (citing articles from authors in various scientific disciplines that “insist[] that fMRI is not ready for the ‘real world’”); *see also, e.g.*, Michael S. Gazzaniga, *The Law and Neuroscience*, 60 *NEURON* 412–13 (2008) (cautioning against the introduction of neuroscience-based lie detection evidence because jurors and judges may erroneously accept such evidence as legally dispositive); James R. Merikangas, *Commentary: Functional MRI Lie Detection*, 36 *J. AM. ACAD. PSYCHIATRY & L.* 499, 501 (2008) (concluding that fMRI lie detection technology does not meet the *Daubert* criteria for courtroom testimony); Rakoff, *supra* note 17, at 40, 44 (arguing that neuroscience-based lie detection “suffers from several defects that would render such evidence inadmissible under [Federal Rule of Evidence] 702”); Joseph R. Simpson, *Functional MRI Lie Detection: Too Good to Be True?*, 36 *J. AM. ACAD. PSYCHIATRY & L.* 491, 493 (2008) (“[H]ow well fMRI lie detection would work in real-life situations remains an open question.”); Spence, *supra* note 71, at 11 (suggesting that fMRI-based lie detection is inapplicable to the “real world” and lacks scientific reliability because no fMRI-based lie detection study has been replicated).

99. *See infra* note 151. This Note proceeds under the strong assumption that the necessary improvements will be made to satisfy the requirements of scientific evidence under the FRE. This assumption is necessary for my analysis under FRE 403. Without these technological improvements, fMRI technology will likely fail to be admitted under FRE 702, obviating an FRE 403 analysis.

100. *See* Mara Boundy, *The Government Can Read Your Mind: Can the Constitution Stop It?*, 63 *HASTINGS L.J.* 1627, 1643 (2012); Pardo, *supra* note 23, at 302. For a complete, in-depth survey of this field and a compilation of scholars’ assertions regarding the interplay between this technology and the Fourth and Fifth Amendments, see Shen, *supra* note 7, at 692–707.

various countermeasures.¹⁰¹ None of these problems, however, seem to pose a fatal threat to its legal application; the technology simply needs more time and funding to strengthen its clinical foundation.¹⁰²

II. RELEVANT EVIDENTIARY RULES

As with all evidence, this technology will be subject to the Federal Rules of Evidence (FRE) before it may be properly admitted in courts. This Note focuses on the effects of this technology within the guilt phase of a criminal jury trial, although it is applicable to other settings as well.¹⁰³ Generally, evidence must be both relevant and authenticated before more specific rules are applied to assess its admissibility.¹⁰⁴ FRE 702 deals broadly with scientific evidence, while FRE 403 requires balancing the value of evidence with issues the evidence presents. The relevant evidence rules, as well as the current evidentiary significance of both polygraph and brain imaging technologies, are discussed in the following sections.

A. Rules

1. Authentication

fMRI images are likely to be introduced as circumstantial, demonstrative evidence relevant to a person's credibility that must be accompanied by expert testimony.¹⁰⁵ "fMRI provides the basis of the expert's opinion by applying neuropsychological models, laws of physics, and statistical principles in order to draw probabilistic conclusions about an individual's brain activity."¹⁰⁶ To be authenticated, the technology must show that the general methodology produces an accurate result, and that the examiner

101. See *infra* Part III.A.3 for a discussion of reliability and validity of results; see also, Adelsheim, *supra* note 97, at 892–905; Langleben & Moriarty, *supra* note 8, at 229–30.

102. Langleben & Moriarty, *supra* note 8, at 230.

103. See generally Feigenson, *supra* note 93; Owen D. Jones & Francis X. Shen, *Law and Neuroscience in the United States*, in INTERNATIONAL NEUROLAW: A COMPARATIVE ANALYSIS 349 (Tade M. Spranger ed., 2012).

104. Brown & Murphy, *supra* note 48, at 1155.

105. Brown & Murphy, *supra* note 48, at 1156–58. One day, fMRI images may be considered testimonial, such as the aforementioned 'guilty knowledge.' *Id.* at 1156. This would implicate the hearsay doctrine and protections against self-incrimination. *Id.* at 1156–57. For a discussion on the Constitutional implications of fMRI technology, see generally Shen, *supra* note 7.

106. Brown & Murphy, *supra* note 48, at 1171.

followed the proper methodology in any particular case.¹⁰⁷ Although there is no “one-size-fits-all” authentication process, admissibility procedures for fMRI will likely follow that of photographs, x-rays, and/or computer-generated simulations.¹⁰⁸ Given more sophistication and obscure methods, each generation of imaging devices requires a higher degree of authentication initially before eventually becoming admitted on a more regular basis.¹⁰⁹

2. *Rule 702*

FRE 702, which pertains to scientific expert testimony,¹¹⁰ will likely be the largest hurdle fMRI deception detection must pass before being admitted in the guilt phase of criminal jury trials.¹¹¹ This Rule was adopted as improvement over the former *Frye* standard, which admitted scientific evidence if it could be “sufficiently established to have gained *general acceptance* in the particular field.”¹¹² FRE 702 states that an expert witness may testify: (1) if his knowledge helps the trier of fact understand evidence; (2) if his knowledge is based on sufficient facts or data; (3) if his testimony is the result of reliable principles and methods; and (4) if he has reliably applied the principles and methods to the facts of the case.¹¹³

FRE 702 was amended in the wake of the landmark *Daubert* case,¹¹⁴ which sanctioned trial judges as gatekeepers, empowering them with the responsibility to assess the scientific validity of evidence before its admission.¹¹⁵ Under *Daubert*, factors to be considered in deciding whether the methodology underlying proffered evidence is reliable or scientifically valid for the purposes of FRE 702 include: (1) the falsifiability of hypotheses and whether the technique used in gathering the evidence has been tested; (2) whether the technique has been subject to peer review; (3) whether there are known or potential error rates and whether there are standards

107. *Id.* at 1164.

108. *Id.* at 1169–70.

109. *Id.*

110. *See* FED. R. EVID. 702.

111. For a discussion of the current technology’s admissibility under FED. R. EVID. 702, see *infra* Part III.A.

112. *Frye v. United States*, 293 F. 1013, 1014 (D.C. Cir. 1923) (emphasis added). Fourteen states still employ this standard. *Brown & Murphy*, *supra* note 48, at 1176.

113. FED. R. EVID. 702.

114. FED. R. EVID. 702 advisory committee’s note (amended in 2000) (noting that the rule was “amended in response to *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993), and to the many cases applying *Daubert*”).

115. *See generally* *Daubert v. Merrell Dow Pharm.*, 509 U.S. 579 (1993).

controlling the technique's operation; and (4) whether the technique has garnered general acceptance in the relevant scientific community.¹¹⁶ Although the *Daubert* Court did not intend for the factors explicated in its holding to constitute a check-list,¹¹⁷ they have since been treated as dispositive factors in determining the admissibility of expert testimony.¹¹⁸ In applying this standard in later cases, the Court further held that expert witnesses cannot unjustifiably extrapolate from an accepted premise to an unfounded conclusion: the data on which an expert relies must fit the facts of the case.¹¹⁹

Importantly, this Note initially proceeds under the assumption that the application of fMRI technology for deception detection purposes will develop its reliability enough to the point of satisfying FRE 702 and its accompanying case law, in order to discuss the potential impact of another FRE that has the ability to bar this technology—FRE 403.

3. Rule 403

The second, more general, rule of evidence that may serve to exclude fMRI deception detection is FRE 403, which states that a “court may exclude relevant evidence if its probative value is *substantially outweighed* by a danger of one or more of the following: unfair prejudice, confusing the issues, misleading the jury, undue delay, wasting time, or needlessly presenting cumulative evidence.”¹²⁰ This Rule is generally viewed as a low bar for admission,¹²¹ applied by courts “only sparingly since the evidence excluded is concededly probative.”¹²² This application requires a court to balance the

116. *Id.* at 593–95.

117. *Id.* at 593 (“Many factors will bear on the inquiry, and we do not presume to set out a definitive checklist or test.”).

118. D. Michael Risinger, *Goodbye to All That, or A Fool’s Errand, by One of the Fools: How I Stopped Worrying About Court Responses to Handwriting Identification (and “Forensic Science” in General) and Learned to Love Misinterpretations of Kumho Tire v. Carmichael*, 43 TULSA L. REV. 447, 460 (2007).

119. *Gen. Elec. Co. v. Joiner*, 522 U.S. 136, 146 (1997) (noting that judges “may conclude that there is simply too great an analytical gap between the data and the opinion proffered”).

120. FED. R. EVID. 403 (emphasis added); see *United States v. Semrau*, No. 07-10074 MJP., 2010 WL 6845092 (W.D. Tenn. June 1, 2010).

121. See 2 JACK B. WEINSTEIN & MARGARET A. BERGER, WEINSTEIN’S FEDERAL EVIDENCE § 403.02 (Joseph M. McLaughlin & Matthew Bender eds., 2d ed. 1997) (updated LexisNexis 2013).

122. *Spain v. Gallegos*, 26 F.3d 439, 453 (3d Cir. 1994) (citing *Blancha v. Raymark Indus.*, 972 F.2d 507, 516 (3d Cir. 1992)); see also John C. Bush, *Warping the Rules:*

evidence's probative value with its various potential negative consequences.¹²³ Further, the *unfair* prejudice that the proffered evidence must engender must not only outweigh its "concededly probative" value, but it must also do so substantially.¹²⁴ It is important to note that, in our adversarial system of justice, attorneys purposely attempt to create prejudice to convince a neutral party of the strength of one's case through proffered evidence.¹²⁵ Thus, judges should not use this rule of evidence merely to level the playing field of the "relative strengths and weaknesses of cases."¹²⁶

B. Technology's Evidentiary Significance

1. *The Polygraph*

fMRI technology's prospects for successful admission have most often been discussed in light of the polygraph's admissibility failure,¹²⁷ which has even been dubbed the "pyrite standard" of unscientific means to ascertain the truth.¹²⁸ The admissibility of polygraph technology has been extensively researched and written about.¹²⁹ Its admissibility was most notably and recently decided upon in *United States v. Scheffer*.¹³⁰ The plaintiff in that case, Edward Scheffer, challenged the military's ban on the use of polygraph technology in court-martial proceedings as a violation of his Sixth Amendment right to present a defense.¹³¹ The United States Court of Appeals for the Armed Forces reversed the court-martial conviction.¹³² The Supreme Court reversed the decision, upholding a *per se* ban on polygraph technology in military court-martial proceedings, stating that the

How Some Courts Misapply Generic Evidentiary Rules to Exclude Polygraph Evidence, 59 VAND. L. REV. 539, 559 (2006).

123. See Fred Galves, *Where the Not-So-Wild Things Are: Computers in the Courtroom, the Federal Rules of Evidence, and the Need for Institutional Reform and More Judicial Acceptance*, 13 HARV. J.L. & TECH. 161, 270 (2000).

124. *Id.*

125. *Id.* at 222.

126. *Id.* at 270.

127. See, e.g., Kittay, *supra* note 35.

128. Keckler, *supra* note 1, at 511.

129. See, e.g., Bush, *supra* note 122; Christopher Domin, *Mitigating Evidence? The Admissibility of Polygraph Results in the Penalty Phase of a Capital Trial*, 43 U.C. DAVIS L. REV. 1461 (2010).

130. 523 U.S. 303 (1998).

131. *Id.*

132. *United States v. Scheffer*, 44 M.J. 442 (C.A.A.F. 1996).

government had a “legitimate interest in ensuring that reliable evidence is presented to the trier of fact in a criminal trial.”¹³³

The Court mainly cited the lack of consensus on polygraph’s reliability as a basis for the legitimate interest in the ban.¹³⁴ Almost all courts have precluded the admission of polygraph evidence, but there are some jurisdictions that permit its inclusion under certain circumstances.¹³⁵ Polygraph technology also has uses outside of the courtroom, such as in negotiation, prosecutorial discretion, and plea agreements.¹³⁶

2. *Brain Imaging*¹³⁷

fMRI deception detection techniques have not yet been admitted in the criminal context. It is widely believed that the first case to admit fMRI evidence whatsoever was in the sentencing phase of a capital punishment case; however, the judge only permitted the fMRI neuroscientist to describe the results of his tests, for fear that showing the fMRI images would over-influence the jury.¹³⁸ If these techniques are admitted into criminal trials at all, it will most likely first occur in the sentencing phase of capital punishment trials, given its relaxed procedural standards.¹³⁹

In an fMRI deception detection case of first impression, the technology’s application was ruled inadmissible in the guilt phase of a federal criminal trial under both FRE 702 and 403 in *United States v.*

133. *Scheffer*, 523 U.S. at 309.

134. *Id.* at 309–12.

135. See Alexander, *supra* note 12, at 31–35; Greely & Illes, *supra* note 52, at 412–13.

136. See, e.g., Mary P. Brown & Steven E. Bunnell, *Negotiating Justice: Prosecutorial Perspectives on Federal Plea Bargaining in the District of Columbia*, 43 AM. CRIM. L. REV. 1063, 1072 n.24 (2006) (mentioning the use of polygraph technology in the context of plea bargaining and prosecutorial discretion).

137. See generally Jones & Shen, *supra* note 103, at 349 (discussing the legal use of brain technology in several different contexts); Pettit, Jr., *supra* note 55, at 334–49. For discussion of use of this technology in the civil context, see Jones et al., *supra* note 58, at 2 (citing O. CARTER SNEAD, NEUROIMAGING AND THE COURTS: STANDARD AND ILLUSTRATIVE CASE INDEX (2006)).

138. Virginia Hughes, *Head Case*, 464 NATURE 340, 341 (2010).

139. “Information is admissible regardless of its admissibility under the rules governing admission of evidence at criminal trials except that information may be excluded if its probative value is outweighed by the danger of creating unfair prejudice, confusing the issues, or misleading the jury.” 18 U.S.C. § 3593(c) (2012). For a comprehensive discussion of neuroimaging within the capital punishment context, see O. Carter Snead, *Neuroimaging and the “Complexity” of Capital Punishment*, 82 N.Y.U. L. REV. 1265 (2007).

Semrau.¹⁴⁰ Although the magistrate judge found that this technology had satisfied *Daubert's* falsifiability and peer review criteria,¹⁴¹ it was deemed inadmissible under FRE 702 because it failed to satisfy the other criteria; “real world” error rates were unknown,¹⁴² there was a lack of controlling standards in the industry,¹⁴³ and the method was not yet generally accepted by the scientific community.¹⁴⁴

The court also ruled the evidence inadmissible under FRE 403 because the tests were unilaterally conducted without informing the government,¹⁴⁵ the defendant sought to admit the results to bolster his credibility before the jury on issues that were central to the case,¹⁴⁶ and the expert witness could not testify to the truthfulness of any specific statement made by the defendant.¹⁴⁷ The presiding judge, however, admitted that the technique might one day be admissible.¹⁴⁸ The Sixth Circuit recently affirmed the decision.¹⁴⁹

III. fMRI UNDER 403

The criteria set forth in *Daubert* are useful in assessing fMRI's probative value for the purposes of determining its admissibility under FRE 403.¹⁵⁰ Even though this Note is premised on the assumption that this technology will eventually satisfy the admissibility standards of FRE 702 under *Daubert* and its progeny, it

140. No. 07-10074 MI/P., 2010 WL 6845092, at *3 (W.D. Tenn. June 1, 2010). fMRI deception detection results were also deemed inadmissible in a New York criminal case under the *Frye* standard. *Wilson v. Corestaff Servs., L.P.*, 900 N.Y.S.2d 639, 640 (Sup. Ct. 2010).

141. *Semrau*, 2010 WL 6845092, at *10.

142. *Id.* at *11–12.

143. *Id.* at *13.

144. *Id.*

145. *Id.* at *4, *15–16 (noting that the defendant could have conducted the test and never have disclosed the results if they were not favorable).

146. *Id.* at *15.

147. *Id.* at *16 (asserting that the expert's ability to only offer an opinion on the general truthfulness of answers to twenty questions as opposed to any specific question would cause danger of unfair prejudice that substantially outweighs any probative value of that opinion).

148. *Id.* at *12 n.18 (“In the future, should fMRI-based lie detection undergo further testing, development, and peer review, improve upon standards controlling the technique's operation, and gain acceptance by the scientific community for use in the real world, this methodology may be found to be admissible even if the error rate is not able to be quantified in a real world setting.”).

149. *United States v. Semrau*, 693 F.3d 510 (6th Cir. 2012).

150. This approach was also taken in *Brown & Murphy*, *supra* note 48, at 1179–1206. The probative value is determined by *Daubert's* factors, which are weighed against FRE 403's various concerns.

is necessary to understand how these factors affect its probative value.¹⁵¹ This Part will discuss each of these factors as they apply to fMRI technology in turn.

A. FRE 702's Probative Value Factors

1. Testability

fMRI deception detection technology has generally satisfied *Daubert's* initial criterion: whether a technique is falsifiable and has been properly tested.¹⁵² Even though *Semrau* accepted this criterion as satisfied,¹⁵³ others disagree, with some going as far as saying that this technique is not even truly testable under ethical constraints.¹⁵⁴ For these critics, in order to satisfy this criterion, researchers would have to get participants to commit a crime and prosecute them for it.¹⁵⁵ Further, the entire research field of fMRI deception detection consists of approximately twenty studies, only four of which test deception at the individual level, yielding results that are inconsistent with one another and that have not been replicated.¹⁵⁶

2. Peer Review

fMRI technology has also generally satisfied *Daubert's* second criterion because the technique has been subjected to peer review and publication.¹⁵⁷ However, much of the peer review is critical of the research: many doubt the reliability of existing results and conclusions due to the lack of replication of most studies.¹⁵⁸ Not only are the

151. Generally speaking, a majority of scholars that have weighed in on the discussion agree that, given the research to date, fMRI deception detection should not be admitted as substantive evidence in a court of law. *See* Adelsheim, *supra* note 97, at 886. For more in-depth discussion as to admissibility of deception detection under the current state of fMRI technology, see, e.g., *id.* at 905–08; Law, *supra* note 86, at 37–44; Meixner, *supra* note 24, at 1476–87; Adam Teitcher, Note, *Weaving Functional Brain Imaging into the Tapestry of Evidence: A Case for Functional Neuroimaging in Federal Criminal Courts*, 80 FORDHAM L. REV. 355 (2011).

152. *Daubert v. Merrell Dow Pharm.*, 509 U.S. 579, 593 (1993). Falsifiability is the quality of being able to be proven false, which is the single most defining characteristic of science. Karl Popper, CONJECTURES AND REFUTATIONS: THE GROWTH OF SCIENTIFIC KNOWLEDGE 37 (5th ed. 1989).

153. *Semrau*, 693 F.3d at 521.

154. *See, e.g.*, Adelsheim, *supra* note 97, at 905–08; Kanwisher, *supra* note 90, at 12.

155. Adelsheim, *supra* note 97, at 906.

156. *Id.* at 907.

157. *Daubert*, 509 U.S. at 593.

158. Adelsheim, *supra* note 97, at 900–01.

reported results different across different labs, some researchers have even had difficulty replicating their own results.¹⁵⁹ Further, many of the studies that support the technology's reliability come from scientists with financial interests in the studies' outcomes¹⁶⁰—a clear conflict of interest by legal standards.¹⁶¹

3. *Known/Potential Rate of Error*

The third factor set forth in *Daubert*, a technique's known or potential error rate,¹⁶² is the most controversial as applied to fMRI technology. Indeed, the assessment and consequential admission of scientific expert evidence under FRE 702 quite possibly hinges on this factor,¹⁶³ as it most directly relates to *evidential reliability*.¹⁶⁴ Proponents assert that fMRI technology can accurately distinguish an individual subject's truthful response from a lie anywhere from seventy-six percent in one study¹⁶⁵ to ninety percent in another.¹⁶⁶ However, critics are quick to point out many faults of the technology and its application in those experiments.

The first set of problems this technology presents with regard to error rates concerns its scientific validity: “does the principle support

159. See *infra* notes 187–96 and accompanying text for a discussion on reliability.

160. Jane C. Moriarty, *Visions of Deception: Neuroimages and the Search for Truth*, 42 AKRON L. REV. 739, 759 (2009).

161. Several scientists who claim that the technology has successfully attained a high level of accuracy are financially tied to its success. See Schauer, *supra* note 74, at 1202 n.53 (“For example, Christos Davatzikos, the lead researcher of the Davatzikos study . . . serves on the Science Board of No Lie MRI Similarly, Frank Kozel, the lead researcher of the three Kozel studies . . . serves as a scientific advisor for Cephus Finally, No Lie MRI uses technology and methods under a license from Daniel Langleben, lead researcher on many other studies”).

162. *Daubert*, 509 U.S. at 594.

163. Schauer & Spellman, *supra* note 5, at 9.

164. “In a case involving scientific evidence, *evidentiary reliability* will be based upon *scientific validity*.” *Daubert*, 509 U.S. at 590 n.9 (noting “that scientists typically distinguish between ‘validity’ . . . and ‘reliability’”). The term “reliability” has similar but distinct meanings in science and the law. See Schauer, *supra* note 74. Scientific reliability is defined as having reproducible results. See Law, *supra* note 86, at 42. Legal reliability is having the quality of “trustworthiness.” *Daubert*, 509 U.S. at 590 n.9.

165. Langleben et al., *Telling Truth*, *supra* note 74, at 271 (concluding that fMRI images may be able to distinguish a truth from a lie on the basis that a lie “appears to be a more working memory-intensive activity, characterized by increased activation of the inferolateral cortex implicated in response selection, inhibition, and generation”).

166. Kozel et al., *Detecting Deception*, *supra* note 74, at 611 (concluding that “fMRI can be used to detect deception within a cooperative individual”); see also, Langleben & Moriarty, *supra* note 8, at 223.

what it purports to show?”¹⁶⁷ One subset of scientific validity problems comes from external and ecological validity¹⁶⁸: extrapolating results from a small number of test subjects to larger populations of people,¹⁶⁹ from the laboratory to the real world.¹⁷⁰ There is a fundamental difference in the foci of science and criminal law¹⁷¹: science is mainly concerned with population-level characteristics, while criminal law focuses mostly on the individual.¹⁷² Due to the prohibitive cost of each scan,¹⁷³ most studies and experiments done with fMRI technology are done with a small number of subjects.¹⁷⁴

167. *Daubert*, 509 U.S. at 590 n.9.

168. Although ecological and external validity are similar to each other and sometimes interchangeably used, they are scientifically distinct concepts. Francis X. Shen & Owen D. Jones, *Brain Scans as Evidence: Truths, Proofs, Lies, and Lessons*, 62 MERCER L. REV. 861, 876–77 (2011).

169. *External* validity is a measure of how much the experimental results can be applied to the general population or individual of interest. *Id.* Concerns with the external validity of most social science research, a concern not unique to deception detection research, has to do with the scientific construction of “normal.” Brown & Murphy, *supra* note 48, at 1149–51 (asserting that the group data to which an individual is compared may not necessarily be “normal” and “[e]ven cutting-edge science has a crude idea of what ‘normal’ means as captured by group data”); Sydney B. Roth, *The Emergence of Neuroscience Evidence in Louisiana*, 87 TUL. L. REV. 197, 215 (2012) (“Being in a certain category of individuals, who might on average be more (or less) susceptible to a certain outcome, does not necessarily mean that everyone in that group of individuals is more (or less) likely to experience that particular outcome.”).

170. *Ecological* validity is a measure of how much experimental laboratory conditions mirror the real world environment. Shen & Jones, *supra* note 168, at 876. One scholar suggests that there might simply be “too great an analytical gap between the data and the opinion proffered” for laboratory deception detection to ever be applicable to real world lying. Adelsheim, *supra* note 97, at 902 (quoting *Gen. Elec. Co. v. Joiner*, 522 U.S. 136, 146 (1997)).

171. *See generally* Schauer, *supra* note 74 (discussing many of the differences between science and the law).

172. Brown & Murphy, *supra* note 48, at 1182–83; David L. Faigman, *A Preliminary Exploration of the Problem of Reasoning From General Scientific Data to Individualized Legal Decision-Making*, 75 BROOK. L. REV. 1115 (2010) (quoting DAVID L. FAIGMAN, *LEGAL ALCHEMY: THE USE AND MISUSE OF SCIENCE IN THE LAW* 69 (1999)) (“[W]hile science attempts to discover the universals hiding among the particulars, trial courts attempt to discover the particulars hiding among the universals.”); Jones & Shen, *supra* note 103, at 356. For discussion of the use of epidemiological data in proving causation, see Schauer, *supra* note 83, at 27 n.59.

173. As of 2009, two private companies, No Lie MRI and Cephos, offered fMRI deception detection services at the cost of \$4000 to \$5000 per scan. *See* Henry T. Greely, *Law and the Revolution in Neuroscience: An Early Look at the Field*, 42 AKRON L. REV. 687, 698 (2009).

174. *See* *United States v. Semrau*, No. 07–10074 MI/P, 2010 WL 6845092, at *11 (W.D. Tenn. June 1, 2010); Gerard, *supra* note 20, at 28; Greely & Illes, *supra* note 52, at 403 (surveying all published fMRI lie detection research through 2006); Schauer, *supra* note 74, at 1201. As of this publication, the largest subject group in

Within these small sample sizes, there is very little cross-cultural variation among the test subjects.¹⁷⁵ Indeed, many of the test subjects in these studies are healthy, upper/middle-class, white, right-handed, male young adults,¹⁷⁶ usually in undergraduate institutions.¹⁷⁷ Further, these non-diverse groups of test subjects often volunteer for these studies, usually receiving class credit or financial compensation for their participation.¹⁷⁸ Most of these experiments focus on detecting deception within the larger group of subjects, as opposed to comparing a single individual's responses, or those between individuals.¹⁷⁹

any peer-reviewed fMRI deception detection article was fifty-two subjects. See Lee et al., *Neural Correlates of Feigned Memory Impairment*, 28 *NEUROIMAGE* 305–13 (2005). However, most experiments were conducted with fewer than thirty subjects. See Spence, *supra* note 71, at 14–21 (surveying peer-reviewed lie detection research through 2007).

175. Semrau, 2010 WL 6845092, at *12; Tommaso Bruni, *Cross-Cultural Variation and fMRI Lie-Detection*, in *TECHNOLOGIES ON THE STAND: LEGAL AND ETHICAL QUESTIONS IN NEUROSCIENCE AND ROBOTICS* 137, 140 (B. Van den Berg & L. Klaming eds., 2011), available at <http://arno.uvt.nl/show.cgi?fid=114416>; Greely & Illes, *supra* note 52, at 403 (stating that fMRI lie detection studies through 2006 had little gender or ethnic diversity).

176. Adelsheim, *supra* note 97, at 899; see Greely & Illes, *supra* note 52, at 403 (discussing the importance of conducting experiments on representative samples). fMRI deception detection research must be conducted on specific sub-populations in order to increase its external validity, including pathological liars, mentally retarded individuals, environmentally damaged individuals, and those with neurodegenerative diseases. See Reese, *supra* note 2, at 219–27.

177. Joel D. Lieberman et al., *Preface to "When Does Sample Matter in Juror Decision-Making Research? Differences Between College Student and Representative Samples of Jurors,"* 29 *BEHAV. SCI. L.* 325, 325–26 (2011) (discussing the applicability of research conducted on college students to the general population). Few significant differences between college student and representative samples have been found. *Id.* Several behavioral research studies generally conclude that "well-designed experiments using subject pools with low incentives can be reliable in predicting the behavior of people in general in real-world situations." Schauer, *supra* note 83 (manuscript at 24). Further, concerns about the applicability of studies that solely use undergraduates as test subjects is not unique to fMRI experiments, as most behavioral studies utilize the same populations. *Id.* at 23.

178. See Semrau, 2010 WL 6845092, at *12; Craig A. Anderson, *Research in the Psychological Laboratory: Truth or Triviality?*, 8 *CURRENT DIRECTIONS PSYCHOL. SCI.* 3, 7 (1999) (asserting that using only undergraduates in experiments limits individual differences, which in turn can exacerbate problems with both internal validity and external reliability); Schauer, *supra* note 74, at 1207.

179. As of this publication, only four out of approximately twenty known fMRI lie detection experiments have been conducted at the individual level. See, e.g., Davatzikos et al., *supra* note 74, at 663; Kozel et al., *Detecting Deception*, *supra* note 74, at 611; Kozel et al., *Pilot Study*, *supra* note 74, at 303; Langleben et al., *Telling Truth*, *supra* note 74, at 262. For the importance of distinguishing results on the individual level from the group or population level, see Greely & Illes, *supra* note 52, at 402.

A separate but related subset of scientific validity problems stem from the manner in which these experiments are set up, which is called *construct* validity. Construct validity is the idea that an experiment actually measures what it purports to measure.¹⁸⁰ The largest problem for fMRI is related to the aforementioned incentive problem: those who volunteer for the studies have a different, and substantially lesser, motivation to lie than criminals who would be criminally investigated with this technology.¹⁸¹ Almost all of the studies that analyze deception have been conducted in controlled laboratory settings, where the results would undoubtedly be more accurate.¹⁸² No research has been done during actual criminal activity or its ensuing investigation,¹⁸³ mainly due to physical and ethical constraints.¹⁸⁴ Some critics even attack the construct validity of many of these experiments on the grounds that test subjects only lie when *instructed* to do so, which, they contend, is different than a *real* lie.¹⁸⁵

180. Schauer, *supra* note 74, at 1201.

181. *See Semrau*, 2010 WL 6845092, at *12 (“Many studies entail little motivation or jeopardy at all, while the motivation (e.g. \$50 for successful deception) or jeopardy (revealing personal autobiographical information) in other studies is not equivalent to what would be at stake in real applications.”) (citations omitted).

182. *Id.*

183. David P. McCabe et. al., *The Influence of fMRI Lie Detection Evidence on Juror Decision-Making*, 29 BEHAV. SCI. & L. 566, 567 (2011).

184. Kanwisher, *supra* note 90, at 12. One ethical constraint is that, in order to truly test the veracity of this technology’s results, experimenters would have to actually know of the commission of a crime and test the criminal before such technology would be permitted as evidence. This creates an ethical dilemma because the experimenters have knowledge of a crime, but would not be permitted to testify to the results in order to conduct clinical trials in fMRI’s application to deception detection. *See, e.g.*, Hakun et al., *supra* note 75, at 519. One physical constraint is the fact that this technology has not been installed in any police precinct due to its prohibitive cost and size, so alleged criminals would have to be transported to and from a laboratory with all the necessary safety precautions that come along with such transportation.

185. Greely & Illes, *supra* note 52, at 404 (“Are lies about participation in a crime the same as lies about the quality of a meal or the existence of a ‘prior engagement’? Do lies about sex activate the same regions of the brain as lies about money, lies to avoid embarrassment, or lies about the five of clubs? Do lies of omission look the same under fMRI as lies of commission?”); Kamila E. Sip et al., *Detecting Deception: The Scope and Limits*, 12 TRENDS COGNITIVE SCI. 48, 50–51 (2008) (arguing that most of these studies have only shown “instructed lies” and not real deception); *cf.* Schauer, *supra* note 74, at 1201, 1208 (arguing that even though the difference between instructed lies and real lies poses a “significant construct validity problem,” the results of these experiments would be completely valueless “only if there were no correlation at all between causes of the brain activity involved in the real lie and those involved in the instructed lie.”); Schauer, *supra* note 83 (manuscript at 25. *But see, e.g.*, Joshua D. Greene & Joseph M. Paxton, *Patterns of Neural Activity Associated with Honest and Dishonest Moral Decisions*, 106 PROC. NAT’L

Further, while not as vulnerable as polygraph technology, some evidence suggests that fMRI technology is still susceptible to countermeasures.¹⁸⁶

A distinct set of problems with regard to fMRI's known error rate is its *reliability*,¹⁸⁷ which is defined as having reproducible results.¹⁸⁸ For lie detection, this entails having the *same* neurological regions activated by lies to the *same* question, in four different contexts: (1) by individuals within a *single* experimental session; (2) by the *same* individual among *different* experimental sessions; (3) among *different* individuals in the *same* experimental session; and (4) among *different* individuals in *different* experimental sessions.¹⁸⁹ Only a handful of studies attempt to discern lies at the individual level; the majority average responses from a group of subjects.¹⁹⁰ Most lie detection studies have not yet been replicated,¹⁹¹ and some replication attempts have even turned up completely contrary results.¹⁹² Further, experimenters in this field use different research paradigms, so their results may not apply to one another's' research.¹⁹³ One scholar argues that the law might be better served by having different reliability standards for evidential admissibility, based on the purposes of the evidence.¹⁹⁴ In this hypothetical regime, a principle

ACAD. SCI. 12506, 12506 (2009) (describing a study involving genuine dishonesty with subject choice); Spence et al., *Speaking of Secrets*, *supra* note 74, at 1411 (conducting a study allowing test subjects to choose when to lie to protect against the potential confounding variable of results reflecting subjects performing instructed actions).

186. Ganis et al., *supra* note 90, at 312 (experimental results showing that subjects can be trained to confound deception detection). In an experiment that involved deceptively answering questions with their fingers, countermeasures included: "to move imperceptibly (i.e., without any overt movement that could be observed) the left index finger, the middle left finger, and the left toe." *Id.* at 313.

187. *See* *Daubert v. Merrell Dow Pharm.*, 509 U.S. 579, 590 n.9 (1993). ("[D]oes application of the principle produce consistent results?") The *Daubert* Court may have originally intended for this criterion to be left out of admissibility determinations of scientific evidence, specifically stating that "*evidentiary reliability* will be based upon *scientific validity*," despite first acknowledging that validity and reliability were two distinct, albeit similar, concepts. *Id.*

188. Langleben & Moriarty, *supra* note 8, at 229.

189. *Id.* A single experimental session would be a group of individuals being a part of an experiment at the same time, in the same place, while different sessions would occur at different times, and possibly in different places. *Id.*

190. *See* Greely & Illes, *supra* note 52, at 402.

191. *Id.* ("A good rule of thumb is to never believe a result until at least one investigator from outside the original group confirms it. Lie detection through fMRI does not pass this test."); Spence, *supra* note 71, at 24.

192. Spence, *supra* note 71, at 24.

193. *Id.* at 13.

194. Schauer, *supra* note 74, at 1205.

piece of evidence that will be used as a cornerstone of a party's case would be subject to a higher bar of reliability before admission.¹⁹⁵ On the other hand, if proffered evidence is just a "piece of the puzzle," then it should be subject to lower standards because a "brick is not a wall."¹⁹⁶

4. *Existence/Maintenance of Standards*

fMRI has probably not satisfied the next *Daubert* criterion,¹⁹⁷ which is the existence and maintenance of standards controlling a technique's operation.¹⁹⁸ As previously mentioned, fMRI technology only shows the movement of deoxygenated blood throughout the brain: this movement still requires much interpretation as to what may properly be deduced.¹⁹⁹ At least one critic points out that there is currently little consistency or transparency as to the standards in this field, or, at the least, that the standards are manipulable.²⁰⁰ Even though fMRI results are less susceptible to subjective interpretation, researchers exercise subjective discretion in creating the results themselves.²⁰¹

5. *General Acceptance in the Scientific Community*

While the scientific community generally has accepted the use of fMRI technology, courts have held that its use for lie detection

195. *Id.* at 1205 n.77 (asserting that higher standards of reliability should be shown when evidence such as DNA identification principally determines whether a defendant goes to jail).

196. *Id.* (quoting 1 MCCORMICK ON EVIDENCE § 185, at 729 (Kenneth S. Broun ed., 6th ed. 2006) (analogizing each piece of evidence to a brick in a wall that a defendant tries to build in his defense)).

197. Adelsheim, *supra* note 97, at 908 ("[T]here simply are no standard techniques at this time.").

198. *Daubert v. Merrell Dow Pharm.*, 509 U.S. 579, 594 (1993).

199. *See* Adelsheim, *supra* note 97, at 888–95, 908 (discussing BOLD fMRI and its inherent weaknesses); Brown & Murphy, *supra* note 48, at 1138–41, 1188 (discussing the various layers along the chain of inferences that must be made in order to create an fMRI image and deduce conclusions from it).

200. Brown & Murphy, *supra* note 48, at 1153 ("Statistical thresholds can therefore be manipulated If a party does not like the results that are shown at a certain level of zoom, simply altering the statistical precision may provide a more compelling image for one's legal argument."); Law, *supra* note 86, at 54 (musing that a proponent can pay an expert to "find" certain results by "simply adjusting the statistical thresholds or the baseline task").

201. Brown & Murphy, *supra* note 48, at 1195 (analogizing fMRI images to paintings instead of photographs, since "[u]nlike photographs, the visual properties of functional brain images are instantiated by the use of texture, shading, perspective, and color").

purposes fails the last *Daubert* criterion of admissibility.²⁰² While some researchers think that it has reached this level,²⁰³ others believe that there should be a moratorium on all non-research use of this fMRI deception detection technology until standards can be established and the field regulated.²⁰⁴ Still others question why the law is using scientific norms and standards to govern the legal realm at all.²⁰⁵ Broadly speaking, there is little general acceptance within the small field of fMRI deception detection researchers, much less the entire scientific community.²⁰⁶ One researcher, who even holds a patent for this technique and stands to financially profit from its success, has publicly stated that it is not yet ready for deployment in the real world.²⁰⁷

B. Unfair Prejudice: Will the Jury Overvalue This Evidence?

The first factor that must be weighed against the potential probative value of fMRI technology is its potential for unfair prejudice.²⁰⁸ Relevant and probative evidence can be barred from admission if the jury would accord such evidence with weight disproportionate to its objective value.²⁰⁹ Fear of jury overvaluation lies at the heart of much of the exclusion of admittedly relevant evidence, especially expert testimony.²¹⁰ However, evidence shows that people do not overvalue neuroscientific images.²¹¹ On the other hand, jurors have been shown in fact to overvalue other types of evidence that are heavily relied upon, especially eyewitness testimony and forensic individualization (including DNA profiling).²¹² This Part examines jurors' views of this technology in more depth.

202. United States v. Semrau, No. 07-10074 MI/P, 2010 WL 6845092, at *13 (W.D. Tenn. June 1, 2010); see *Daubert*, 509 U.S. at 594.

203. See, e.g., Teitcher, *supra* note 151, at 366.

204. See Greely & Illes, *supra* note 52, at 413.

205. See generally Schauer, *supra* note 74, at 1191, 1202-09; Schauer & Spellman, *supra* note 5.

206. Adelsheim, *supra* note 97, at 908.

207. *Id.* at 905-06, 908 (citing Moriarty, *supra* note 160, at 748).

208. FED. R. EVID. 403.

209. Richard D. Friedman, *Minimizing the Jury Over-Valuation Concern*, 2003 MICH. ST. L. REV. 967, 968.

210. See Schauer & Spellman, *supra* note 5, at 5.

211. See *infra* Part III.B.1.

212. See *infra* Part III.B.2.

1. *Jurors Will Not Overvalue Neuroimaging Evidence*

Initial scholarship gave credence to the idea that people were overly swayed by neuroscientific explanations and imagery.²¹³ Those who claim that neuroscientific evidence would have an undue influence on jury members pointed to a “Christmas tree phenomenon,”²¹⁴ in that juries would be excessively persuaded by such images because they would be presented in the form of beautiful graphs with many bright colors.²¹⁵ These claims began even before the advent of fMRI technology.²¹⁶ Several studies outlined below have attempted to show how fMRI imaging would engender unfair prejudice. Almost all of these studies, however, suffer from various external and construct validity problems,²¹⁷ and none of them found the undue prejudice they sought.

a. *Gurley & Marcus (2008)*

An early study, conducted by Jessica R. Gurley and David K. Marcus, contended that jurors were more likely to return a result of “not guilty by reason of insanity” when presented with structural images of brain damage to defendants.²¹⁸ There are several reasons why this study is not applicable to fMRI lie detection. First, the experiment uses *structural* images, which depicts the brain at rest,²¹⁹ as opposed to the *functional* time-lapse images that fMRI provides when subjecting subjects to tasks, which is the subject of this Note. Second, the experiment failed to dissociate the brain images from the

213. See, e.g., Joseph Dumit, *Objective Brains, Prejudicial Images*, 12 SCI. CONTEXT 173 (1999).

214. Dean Mobbs et al., *Law, Responsibility, and the Brain*, 5 PUB. LIBR. SCI. BIOLOGY 0693, 0699 (2007), available at <http://www.plosbiology.org/article/doi/10.1371/journal.pbio.0050103>&represent=PDF.

215. Kevin Davis, *Brain Trials: Neuroscience Is Taking a Stand in the Courtroom*, A.B.A. J. (Nov. 1, 2012), http://www.abajournal.com/magazine/article/brain_trials_neuroscience_is_taking_a_stand_in_the_courtroom; see also Gerard, *supra* note 20, at 28–29.

216. Dumit, *supra* note 213, at 175, 180, 187 (discussing images created by computerized tomography (CT) and positron emission tomography (PET)).

217. For a discussion on external and construct validity, see *supra* notes 168–94 and accompanying text.

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

219. McCabe et al., *supra* note 183, at 568.

expert testimony;²²⁰ thus, the question of whether it was the testimony or the images that produced the effect cannot be determined.²²¹

b. Weisberg et al. (2008)

Another study, conducted by Deena S. Weisberg *et al.*, asserted that people were more likely to believe explanations of events when they included neuroscientific language than the same explanations without such language.²²² However, the authors themselves recognized the major limitation of their findings, stating, “people may be responding to some more general property of the neuroscience information.”²²³ Most importantly, this study did not even measure the effect of brain images.²²⁴ Further, subjects were not tested in a legal setting.²²⁵

c. McCabe & Castel (2008)

A third study, conducted by David P. McCabe and Alan D. Castel, argued that neuroscientific explanations were more influential when accompanied by brain images than when accompanied by bar graphs.²²⁶ There were several problems with these results. First, subjects were asked to compare articles with brain images in each part of the experiment; there was no control condition in which a subject was asked to evaluate the article without a brain image altogether.²²⁷

220. Adina L. Roskies *et al.*, *Neuroimages in Court: Less Biasing than Feared*, 17 *TRENDS COGNITIVE SCI.* 99, 99 (2013), available at <http://download.cell.com/trends/cognitive-sciences/pdf/PIIS1364661313000223.pdf?intermediate=true>.

221. *Id.* (citing N.J. Schweitzer & Michael J. Saks, *Neuroimage Evidence and the Insanity Defense*, 29 *BEHAV. SCI. L.* 592, 596–97 (2011)); N.J. Schweitzer *et al.*, *Neuroimages as Evidence in a Mens Rea Defense: No Impact*, 17 *PSYCHOL. PUB. POL'Y & L.* 357, 361 (2011) [hereinafter Schweitzer *et al.*, *No Impact*] (stating that the experiments “confounded the presentation of neuroimagery with additional verbal testimony”).

222. Deena S. Weisberg *et al.*, *The Seductive Allure of Neuroscience Explanations*, 20 *J. COGNITIVE NEUROSCIENCE* 470, 476 (2008).

223. *Id.*

224. Martha J. Farah & Cayce J. Hook, *The Seductive Allure of “Seductive Allure,”* 8 *PERSP. PSYCHOL. SCI.* 88, 89 (2013); Roskies *et al.*, *supra* note 220, at 99; Schweitzer *et al.*, *No Impact*, *supra* note 221, at 361.

225. Roskies *et al.*, *supra* note 220, at 99; Schweitzer *et al.*, *No Impact*, *supra* note 221, at 360.

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

227. Robert B. Michael *et al.*, *On the (Non)persuasive Power of a Brain Image*, *PSYCHONOMIC BULL. REV.* (Feb. 2013), [http://www.researchgate.net/publication/235523242_On_the_\(non\)persuasive_power_of_a_brain_image](http://www.researchgate.net/publication/235523242_On_the_(non)persuasive_power_of_a_brain_image). A growing body of evidence suggests that *any* kind of image increases probative value of accompanying

Second, much like the pitfall in the Gurley and Marcus study, the neuroscience *language* contained in the study likely already influenced subjects;²²⁸ this Note is concerned with the effect of *imaging*. Moreover, critics argue that the images themselves weren't equivalent to each other.²²⁹ Additionally, this experiment was not conducted in a legal setting.²³⁰ Perhaps most importantly, when the raw data from this experiment and an attempted replication of it were combined, other researchers suggested that McCabe and Castel's purported conclusions were unsubstantiated.²³¹ That is, when other experimenters attempted to replicate the study's results, they instead found that the brain image exerted "little to no independent influence on juror verdicts."²³²

d. McCabe et al. (2011)

A fourth study, conducted by David P. McCabe et al., suggested that verbally offered fMRI lie detection evidence was more influential than lie detection evidence yielded from polygraph or thermal facial imaging technology offered in the same form.²³³ This experiment's major shortcoming is that it fails to compare the effect of such verbal evidence with the effect of neuroimages²³⁴: verbal neuroscientific evidence is already permissible from expert witnesses in criminal cases.²³⁵ Much like the limitation of the Weisberg et al. experiment, this study does not measure the effect of fMRI imaging. Of further note, this influence was negated when the technology's scientific

propositions. See Feigenson, *supra* note 93, at 233 (discussing the inflation of probative value enjoyed by *all* visual images). See generally Lucille A. Jewel, *Through A Glass Darkly: Using Brain Science and Visual Rhetoric to Gain a Professional Perspective on Visual Advocacy*, 19 S. CAL. INTERDISC. L.J. 237, 245 (2010) (discussing the advantages of visual advocacy).

228. See Michael et al., *supra* note 227.

229. Farah & Hook, *supra* note 224, at 88 (stating that it was "not strictly true" that the illustrations used in these two conditions were "informationally equivalent").

230. See Roskies et al., *supra* note 220, at 1; see also Schweitzer et al., *No Impact*, *supra* note 221, at 361 ("[J]udgments of the participants in these experiments [were] made without the competing overlay of crime-guilt-punishment.").

231. Michael et al., *supra* note 227, at 2. The compilation of raw data from identical, yet separately conducted, experiments is called a "meta-analysis." Meixner, *supra* note 24, at 1466 n.107.

232. Michael et al., *supra* note 227, at 5.

233. See McCabe et al., *supra* note 183, at 574 (2011) (stating additionally that fact patterns containing fMRI lie detection evidence was more influential than fact patterns without any such evidence).

234. See *id.* at 571.

235. See O. Carter Snead, *Neuroimaging and the "Complexity" of Capital Punishment*, 82 N.Y.U. L. REV. 1265, 1272 (2007).

validity was called into question within the experiment's fact pattern.²³⁶

e. Greene & Cahill (2012)

Another study, conducted by Edith Greene and Brian S. Cahill, argued that mock jurors were less likely to recommend a sentence of death for defendants at high risk of future dangerousness when given neuropsychological and neuroimaging evidence than when they were given neither.²³⁷ However, visual representations of brain abnormalities did not have a more profound impact on jurors' decisions than neuropsychological testing results alone.²³⁸ The authors suggested that *any* additional information may have affected the jurors decisions.²³⁹ According to these scholars, "[w]hen [brain scans] *do* have an impact . . . it is *no greater* than the impact of neuropsychological testing data that have been available for many decades."²⁴⁰

f. Schweitzer et al. (2011)

The most compelling study exploring the undue influence of neuroimaging found that neuroimaging did *not* affect jurors' judgments any more than verbal neuroscience-based testimony.²⁴¹ Several scholars understood the shortcomings of the aforementioned experiments, and undertook to try to expand or replicate them.²⁴² The four experiments within the study were designed to account for all of the variables that may have confounded the results of the aforementioned studies.²⁴³ "In each successive experiment[,] the

236. See McCabe et al., *supra* note 183, at 574. See *infra* Part III.C.5 for a discussion on cross-examination and its effects.

237. See Edith Greene & Brian S. Cahill, *Effects of Neuroimaging Evidence on Mock Juror Decision Making*, 30 BEHAV. SCI. L. 280, 293 (2012).

238. See *id.*

239. See *id.* ("It may be that any additional information pertinent to the defendant's physical and emotional disposition has the effect of personalizing him to jurors and enhancing their impressions of him . . .").

240. *Id.* at 294 (emphasis added); see also Schauer, *supra* note 83, (manuscript at 37–38) ("The precise question to be asked about fMRI evidence therefore, is . . . whether the inflated value they produce is greater than the inflated value produced by the visual evidence that the legal system routinely admits.").

241. See Schweitzer et al., *No Impact*, *supra* note 221.

242. See Law, *supra* note 86, at 53 ("When the general population relies on primary experimental findings rather than review articles and textbook knowledge, scientists must become proactive.").

243. See Schweitzer et al., *No Impact*, *supra* note 221, at 365 (describing the study's numerous control conditions). Experimenters conducted the experiments in a legal

pressures on mock jurors to find guilt [were reduced] (thus potentially liberating them to be increasingly open to influence from the neuroimage evidence).”²⁴⁴ Even though most of the authors of this study expected these images to unduly influence the mock jurors,²⁴⁵ they concluded, “neuroimages had no especially potent or consistent impact on verdicts or sentences.”²⁴⁶ Describing this turn of events, another scholar stated, “[g]iven the visual appeal of images and their high-tech origins, the idea that they are inordinately persuasive is plausible. This a priori plausibility may have reduced scrutiny of the experimental designs and results that seem to support it.”²⁴⁷

2. Jurors Currently Overvalue Other Types of Evidence

Jurors currently ascribe more weight than they should to certain kinds of admissible evidence based on that evidence’s lack of objective value. As explained in the sections below, eyewitness testimony is notoriously unreliable, and yet it is continuously admitted, and strongly relied upon by jurors. Jurors also award excessive weight to forensic evidence, such as fingerprint and DNA evidence.

a. Eyewitness Testimony

Empirical research has effectively established that eyewitness testimony is unreliable.²⁴⁸ Humans have limited cognitive capacities

setting. *See id.* The “neuroimage condition,” where a subject would be shown a brain scan as well as having it described by accompanying testimony based on the brain scan, was compared to various other control groups: (1) one group hearing the identical neuroscience expert testimony accompanied by a graphical depiction of the defendant’s brain function; (2) one group hearing the identical neuroscience expert testimony accompanied by a generic image of an empty courtroom; (3) one group hearing an expert witness’ testimony that had the same substantive conclusions and diagnoses as the previous group, but which was based on non-neuroimaging techniques; (4) one group hearing the expert witness testimony of a clinical psychologist; and (5) the control group, with the absence of expert testimony altogether. *Id.*

244. *Id.* at 387.

245. *See id.* at 388.

246. *Id.* at 387.

247. Farah & Hook, *supra* note 224, at 89 (asserting that the cognitive heuristic of “confirmation bias” may have clouded some experimenters’ judgments and conclusions).

248. *See* Richard S. Schmechel et al., *Beyond the Ken? Testing Jurors’ Understanding of Eyewitness Reliability Evidence*, 46 JURIMETRICS 177, 179 (2006) (citing Saul Kassin et al., *On the “General Acceptance” of Eyewitness Testimony Research: A New Survey of the Experts*, 56 AM. PSYCHOLOGIST 405, 413–14 (2001)) (asserting that a 2001 survey of established eyewitness researchers found nearly

and are subject to biases and limitations,²⁴⁹ including, importantly, those of memory and perception,²⁵⁰ which lead them to be poor eyewitnesses.²⁵¹ Among other findings, studies have shown that human memory is malleable and rather ephemeral;²⁵² people are far better at recognizing the faces of people in their own race than they are those of a different race,²⁵³ and a witness' confidence has little to no correlation with the accuracy of his or her testimony.²⁵⁴

Jurors have very little awareness of these findings, despite the fact that they have been widely established for some period of time.²⁵⁵ Perhaps most importantly, most people have very little understanding of the stages and faults of human memory storage and recall,²⁵⁶ leading them to grossly overestimate a witness' ability to retain memories.²⁵⁷ Even judges and attorneys themselves are not completely familiar with the shortcomings of eyewitness testimony.²⁵⁸

unanimously that several findings of eyewitness testimony deficiencies were reliable and established in scientific literature).

249. See Chris W. Sanchirico, "What Makes the Engine Go?" *Cognitive Limitations and Cross-Examination*, 14 WIDENER L. REV. 507, 510 n.10 (citing over twenty empirical studies and articles that point out how various cognitive limitations and biases cause people to be poor witnesses).

250. See Schauer & Spellman, *supra* note 5, at 12, nn.40, 42–43 (citing many sources that point to the fact that witness perception is poor and not nearly as reliable as most people believe).

251. See *id.* (asserting that the shortcomings in perception and memory may contribute to the negative effects).

252. See generally Henry F. Fradella, *Why Judges Should Admit Expert Testimony on the Unreliability of Eyewitness Testimony*, 2007 FED. CTS. L. REV. 3 (2007); see also Jacob L. Zerkle, *I Never Forget A Face: New Jersey Sets the Standard in Eyewitness Identification Reform*, 47 VAL. U. L. REV. 357 (2012).

253. See Tara Anthony et al., *Cross-Racial Facial Identification: A Social Cognitive Integration*, 18 PERSONALITY & SOC. PSYCHOL. BULL. 296 (1992).

254. See Jennifer L. Overbeck, *Beyond Admissibility: A Practical Look At the Use of Eyewitness Expert Testimony in the Federal Courts*, 80 N.Y.U. L. REV. 1895, 1900–01 (2005). Other findings include: (1) stressful situations reduce a person's ability to successfully recall facial details; (2) witnesses overestimate how long it took for an event to unfold; and (3) the presentation format affects recall ability because a person is more likely to misidentify a defendant if he is presented in a group. See Schmechel et al., *supra* note 250, at 178.

255. See Schmechel et al., *supra* note 248, at 192.

256. See generally Fradella, *supra* note 252; Zerkle, *supra* note 252.

257. See Overbeck, *supra* note 254, at 1904. This is especially true when eyewitnesses display confidence in their memory. See Schauer & Spellman, *supra* note 5.

258. See Richard A. Wise & Martin A. Safer, *A Survey of Judges' Knowledge and Beliefs About Eyewitness Testimony*, 40 CT. REV. 6, 9 (2003) (showing that two-thirds of judges surveyed gave incorrect answers for three out of six questions that assess understanding of the link between eyewitness confidence and accuracy).

Given the shortcomings in eyewitness testimony, and the lack of general awareness of those shortcomings, jurors tend to overvalue the intrinsic worth of such evidence.²⁵⁹ Jurors place more weight on eyewitness testimony than on other types of evidence, and are substantially more likely to convict defendants when they hear such testimony than when none is available.²⁶⁰ Before the development of forensic DNA testing, mistaken eyewitness identifications were responsible for the convictions of more innocent persons than any other combination of factors.²⁶¹ More recent studies of conviction reversals due to DNA testing indicate that a significant percentage of these reversals involved an eyewitness identification that turned out to false²⁶²—in some studies, as much as eighty-five percent²⁶³—making eyewitness testimony the “single greatest cause of wrongful convictions in this country.”²⁶⁴ For this reason, courts have increasingly permitted expert testimony that addresses the inaccuracy of eyewitness testimony, human memory, and false confessions.²⁶⁵

b. Forensic Evidence

Forensic science is continuously admitted under *Daubert* and FRE 702 with very little hesitation, despite its deficiencies and lack of

259. See Overbeck, *supra* note 254, at 1903–04; Schauer & Spellman, *supra* note 5, at 28; Schmechel et al., *supra* note 248, at 193–204 (citing a study that showed a substantial majority of a thousand-person jury pool in the District of Columbia lacked a meaningful understanding of eyewitness deficiencies and overestimated the value of eyewitness testimony as a result).

260. See Overbeck, *supra* note 254, at 1897–98.

261. See Jacqueline McMurtrie, *The Role of the Social Sciences in Preventing Wrongful Convictions*, 42 AM. CRIM. L. REV. 1271, 1275 n.18 (2005) (citing several studies of wrongful convictions that suggested that a majority of them involved false eyewitness testimony).

262. See Brandon L. Garrett, *Judging Innocence*, 108 COLUM. L. REV. 55, 60 (2008) (stating that seventy-nine percent of the first 200 people exonerated by post-conviction DNA testing were convicted using incorrect eyewitness testimony); see also Overbeck, *supra* note 254, at 1896 n.2 (citing studies that showed that two-thirds of total exonerations were in cases where convictions were based at least in part on faulty eyewitness identifications).

263. See Wes R. Porter, *Repeating, Yet Evading Review: Admitting Reliable Expert Testimony in Criminal Cases Still Depends Upon Who Is Asking*, 36 RUTGERS L. REC. 48, 52 n.28 (2009) (citing McMurtrie, *supra* note 261, at 1275 n.17) (asserting that false eyewitness testimony accounted for as much as eighty-five percent of convictions later exonerated by DNA testing).

264. See *Perry v. New Hampshire*, 132 S. Ct. 716, 738 (2012) (Sotomayor, J., dissenting) (citing *State v. Henderson*, 27 A.3d 872, 886 (N.J. 2011)).

265. See Pardo, *supra* note 23, at 318; see also Schauer & Spellman, *supra* note 5, at 13. See generally Schmechel et al., *supra* note 250, at 178 (discussing various legal trends that have contributed to reforms in the use of eyewitness identification).

scientific validity.²⁶⁶ Forensic individualization methods, most notably fingerprint and DNA analysis, rely on statistic probabilities and subjects' individuality in order to match a piece of evidence with its origin.²⁶⁷ DNA typing was recognized as a large breakthrough for criminal investigation immediately after its advent in the 1980s²⁶⁸; some scholars have even asserted that DNA typing technology paved the way for the *Daubert* decision's overhaul in expert witness testimony admissibility standards.²⁶⁹ Ironically, even though proponents of DNA technology assert that fingerprinting is currently more reliable than DNA,²⁷⁰ some scholars assert that fingerprinting technology might be deemed inadmissible if its admission were sought under the current *Daubert* standard.²⁷¹ Accordingly, DNA evidence is now touted as the "gold standard" of evidence.²⁷²

Despite this "aura of credibility," forensic individualization is not without shortcomings.²⁷³ Even though some scholars still challenge

266. For an in-depth discussion on the shortcomings of forensic science and the expected disparity in admissibility standards when defendants will seek to admit fMRI technology, see generally Teitcher, *supra* note 151.

267. See *id.* at 375–85 (listing other bases of methods and evidence including shoe prints, bite marks, tool marks, firearms, handwriting, and hair samples).

268. See Brooke G. Malcom, *Convictions Predicated on DNA Evidence Alone: How Reliable Evidence Became Infallible*, 38 CUMB. L. REV. 313, 313 (2008).

269. See Margaret A. Berger, *Expert Testimony in Criminal Proceedings: Questions Daubert Does Not Answer*, 33 SETON HALL L. REV. 1125, 1129 (2003); see also David L. Faigman, *The Tipping Point in the Law's Use of Science: The Epidemic of Scientific Sophistication that Began with DNA Profiling and Toxic Torts*, 67 BROOK. L. REV. 111, 112 (2001).

270. See COMM. ON DNA TECH. IN FORENSIC SCI., NAT'L RESEARCH COUNCIL, DNA TECHNOLOGY IN FORENSIC SCIENCE 157 (1992).

271. See Berger, *supra* note 269, at 1139. "Looked at through the lens of *Daubert*, fingerprints clearly should not be admissible and yet fingerprint matches obviously are often accurate and corroborated by other evidence." *Id.* Despite the fact that "there seem[s] to be an endless number of possible permutations consisting of loops, whorls, arches and deltas," the theory that this "abundance of detail probably makes each individual's fingerprint pattern unique . . . has never been scientifically verified." *Id.*; see also, Roger C. Park & Michael J. Saks, *Evidence Scholarship Reconsidered: Results of the Interdisciplinary Turn*, 47 B.C. L. REV. 949, 981–82 (2006) ("What lawyers, scholars, and the courts are discovering is that some kinds of evidence, most notably some of the forensic sciences, which had been all but unquestioned under older admissibility tests, appeared to have startling weaknesses when viewed through the lens of the new test."). See generally, Robert Epstein, *Fingerprints Meet Daubert: The Myth of Fingerprint "Science" is Revealed*, 75 S. CAL. L. REV. 605 (2002).

272. See Joseph L. Peterson & Anna S. Leggett, *The Evolution of Forensic Science: Progress Amid the Pitfalls*, 36 STETSON L. REV. 621, 654 (2007).

273. See Jason Schklar & Shari S. Diamond, *Juror Reactions to DNA Evidence: Errors and Expectations*, 23 L. & HUM. BEHAV. 159, 159 (1999).

the individualization theory underlying forensic science generally,²⁷⁴ and many of these methods have little to no scientific basis,²⁷⁵ the applications to DNA, and fingerprint analysis to a lesser extent,²⁷⁶ have generally been proven reliable.²⁷⁷ Yet, there is a general lack of standardization and regulation within and among fields of forensic science.²⁷⁸ Further, given that experts must interpret the evidence, there is the omnipresent specter of human error²⁷⁹ and susceptibility to psychological biases.²⁸⁰ For example, in one study, when fingerprint examiners were given the same set of fingerprints again, examiners reached different conclusions ten percent of the time.²⁸¹ Forensic experts have often failed to conduct adequate testing, or improperly exaggerate warranted conclusions from the data.²⁸² In fact, some form of invalid or improper forensic evidence may have contributed to over half of the original convictions later exonerated by DNA evidence.²⁸³

274. See Jonathan J. Koehler & Michael J. Saks, *Individualization Claims in Forensic Science: Still Unwarranted*, 75 BROOK. L. REV. 1187, 1192 (2010) (asserting that the ability of any forensic science, with the notable exception of DNA typing, to individualize any material as *completely* unique has never been proven).

275. See generally David L. Faigman, *Anecdotal Forensics, Phrenology, and Other Abject Lessons from the History of Science*, 59 HASTINGS L. J. 979 (2008); see also Teitcher, *supra* note 151, at 379 & n.217.

276. See Andrew C. Bernasconi, *Beyond Fingerprinting: Indicting DNA Threatens Criminal Defendants' Constitutional and Statutory Rights*, 50 AM. U. L. REV. 979, 1009 (2001) ("Researchers theoretically have the ability to obtain and analyze all of the information fingerprints provide.").

277. See Teitcher, *supra* note 151, at 382 & n.243 (citing COMM. ON IDENTIFYING THE NEEDS OF THE FORENSIC SCIS. CMTY., NAT'L RESEARCH COUNCIL, STRENGTHENING FORENSIC SCIENCES IN THE UNITED STATES: A PATH FORWARD 7 (2009) [hereinafter NAT'L RESEARCH COUNCIL, STRENGTHENING FORENSIC SCIENCES]).

278. See *id.* at 382 & n.244 (citing NAT'L RESEARCH COUNCIL, STRENGTHENING FORENSIC SCIENCES, *supra* note 277, at 7–8).

279. See Berger, *supra* note 269, at 1129.

280. See Itiel E. Dror & Simon A. Cole, *The Vision in Blind Justice: Expert Perception, Judgment, and Visual Cognition in Forensic Pattern Recognition*, 17 PSYCHONOMIC BULL. & REV. 161, 162 (2010), available at <http://dx.doi.org/10.3758/PBR.17.2.161>; see also Itiel E. Dror & Robert Rosenthal, *Meta-Analytically Quantifying the Reliability and Biasability of Forensic Experts*, 53 J. FORENSIC SCI. 900, 900 (2008).

281. See Bradford T. Ulery et al., *Repeatability and Reproducibility of Decisions by Latent Fingerprint Examiners*, 7 PUB. LIBR. SCI. ONE e32800, 1 (2012), available at <http://www.plosone.org/article/info:doi/10.1371/journal.pone.0032800>.

282. See Saul M. Kassin et al., *The Forensic Confirmation Bias: Problems, Perspectives, and Proposed Solutions*, 2 J. APPLIED RES. MEMORY & COGNITION 42, 43 (2013).

283. See *id.* (citing BRANDON L. GARRETT, *CONVICTING THE INNOCENT: WHERE CRIMINAL PROSECUTIONS GO WRONG* (Harvard Univ. Press ed., 2011)); see also,

Because of its deficiencies, jurors have a propensity to overvalue forensic evidence—even DNA profiling.²⁸⁴ One study showed that, without adequate explanation, many jurors are not able to accurately assess the reliability of DNA profiling methods.²⁸⁵ Despite this weakness, jurors in the same study that had greater pretrial trust in DNA evidence were more likely to convict the defendant.²⁸⁶ Alarming, in another study, the “increase in [jurors’] perceived probative value [of all the evidence] was most prominent when the DNA evidence was of a *moderate or weak* standard.”²⁸⁷ Some mock jurors in yet another study practically disregarded statistically significant laboratory error rates when given an extremely low “random match probability;”²⁸⁸ this was probably caused at least partially by the difficulty many jurors face when trying to comprehend statistical information.²⁸⁹ Prosecutors exacerbate the problem with various misstatements and exaggerations.²⁹⁰

C. Confusing the Issue

The second factor under FRE 403 that must be weighed against the probative value of the use of fMRI for detection of deception under is its potential to confuse the jury,²⁹¹ or even judges.

1. Juror Problems

Evidence shows that jurors’ fact-finding abilities are generally sound.²⁹² From there, however, empirical evidence paints a much

NAT’L RESEARCH COUNCIL, STRENGTHENING FORENSIC SCIENCES, *supra* note 277, at 42 (noting that forensic science had led to a “disturbing number of wrongful convictions”).

284. See Joel D. Lieberman et al., *Gold Versus Platinum: Do Jurors Recognize the Superiority and Limitations of DNA Evidence Compared to Other Types of Forensic Evidence?*, 14 PYSCHOL. PUB. POL’Y & L. 27, 56–57 (2008).

285. See *id.* at 50.

286. See *id.* at 52.

287. Lisa L. Smith et al., *Understanding Juror Perceptions of Forensic Evidence: Investigating the Impact of Case Context on Perceptions of Forensic Evidence Strength*, 56 J. FORENSIC SCI. 409, 413 (2011) (emphasis added).

288. See Jonathan J. Koehler et al., *The Random Match Probability in DNA Evidence: Irrelevant and Prejudicial?*, 35 JURIMETRICS J. 201, 216 (1995).

289. See *infra* notes 292–99 and accompanying text.

290. See Koehler et al., *supra* note 288, at 211 n.39 (giving examples of prosecutorial claims, such as “DNA is infallible,” or “an incorrect match is impossible”).

291. FED R. EVID. 403.

292. See Joe S. Cecil et al., *Citizen Comprehension of Difficult Issues: Lessons From Civil Jury Trials*, 40 AM. U. L. REV. 727, 750 (1991); George Fisher, *The Jury’s Rise as Lie Detector*, 107 YALE L.J. 575, 705 (1997); Valerie P. Hans, *Science in the*

more dismal picture of the jury, especially its interaction with science and mathematics. Case studies of juror performance in complex cases suggest that jurors have difficulty in comprehending and properly using scientific evidence.²⁹³ Jurors are particularly challenged when evaluating science based on statistical data.²⁹⁴ Even more troublesome is what some scholars call the “gatekeeper effect,” where jurors imbue low-quality expert testimony with undeserved credibility simply because they think judges inspect evidence themselves before its admission.²⁹⁵

Jurors also have trouble identifying serious flaws in experimental setup and how these flaws affect the internal validity of the results.²⁹⁶ The only major flaw that jurors are able to consistently detect is a missing control group;²⁹⁷ jurors are not very capable of identifying other confounding variables that have the potential to compromise an experiment’s results.²⁹⁸ For example, jurors have distinct trouble identifying an experimenter’s bias.²⁹⁹ Nevertheless, it may not completely be the jurors’ fault; at the very least, they are not alone, as some judges have similar difficulties.

2. Judge Problems

Studies suggest that judges are not much better than jurors at assessing scientific evidence. Even though their self-confidence may

Jury Box: Jurors’ Comprehension of Mitochondrial DNA Evidence, 35 L. & HUM. BEHAV. 60 (2011).

293. See N.J. Schweitzer & Michael J. Saks, *Jurors and Scientific Causation: What Don’t They Know, and What Can Be Done About It?*, 52 JURIMETRICS 433, 434 (2012) (citing Cecil et al., *supra* note 292, at 752–56) (providing case studies of juror performance in complex cases).

294. See, e.g., Hans, *supra* note 292, at 61; Suzanne O. Kaasa et al., *Statistical Inference and Forensic Evidence: Evaluating a Bullet Lead Match*, 31 L. & HUMAN BEHAV. 433, 433 (2006); Joseph Sanders, *The Merits of the Paternalistic Justification for Restrictions on the Admissibility of Expert Evidence*, 33 SETON HALL L. REV. 881, 907 (2003); Schweitzer & Saks, *supra* note 293, at 434 (citing Ulrich Hoffrage et al., *Communicating Statistical Information*, 290 SCI. 2261, 2261 (2000)).

295. See N.J. Schweitzer & Michael J. Saks, *The Gatekeeper Effect: The Impact of Judges’ Admissibility Decisions on the Persuasiveness of Expert Testimony*, 15 PSYCHOL. PUB. POL’Y & L. 1, 1 (2009) (asserting that judges inadvertently endorse the credibility of poor quality evidence by letting it into suits).

296. See Bradley D. McAuliff & Tejah D. Duckworth, *I Spy With My Little Eye: Jurors’ Detection of Internal Validity Threats in Expert Evidence*, 34 L. & HUM. BEHAV. 489 (2010).

297. See *id.* at 497.

298. See *id.*

299. See *id.*

overestimate their actual ability,³⁰⁰ judges are human, after all, and are thus subject to many, if not all, of the same cognitive shortcomings.³⁰¹ In the same vein, judges are also prone to misunderstanding statistical information.³⁰² After surveying four hundred state court judges, some scholars went so far as to say that judges “lack the scientific literacy required for a *Daubert* analysis.”³⁰³ The same study even suggests that only about five percent of those judges could demonstrate a clear understanding of falsifiability or error rates.³⁰⁴ Judges, like jurors, also “have difficulty identifying methodologically flawed expert testimony.”³⁰⁵ Judges may err on the side of caution when applying a *Daubert* analysis, with some empirical research suggesting that judges are more likely to exclude evidence the more quantitatively complex it is.³⁰⁶

300. See Frederick Schauer, *On the Supposed Jury-Dependence of Evidence Law*, 155 U. PA. L. REV. 165, 190–91 (2006) (extrapolating this conclusion from comparisons between actuarial and clinical predictions of future dangerousness).

301. See Chris Guthrie et al., *Inside the Judicial Mind: Heuristics and Biases*, 86 CORNELL L. REV. 777, 821 (2001) (showing that judges were influenced by cognitive heuristics such as anchoring, framing effects, hindsight bias, representativeness, and egocentric biases); Barbara A. Spellman, *On the Supposed Expertise of Judges in Evaluating Evidence*, 156 U. PA. L. REV. 1, 4–6 (2007).

302. See Neil Vidmar & Shari S. Diamond, *Juries and Expert Evidence*, 66 BROOK. L. REV. 1121, 1170 (2001) (citing THE EVOLVING ROLE OF STATISTICAL ASSESSMENTS AS EVIDENCE IN THE COURTS (Stephen E. Fienberg ed., 1989)).

303. See McAuliff & Duckworth, *supra* note 296, at 489 (citing Sophia Gatowski et al., *Asking the Gatekeepers: A National Survey of Judges on Judging Expert Evidence in a Post-Daubert World*, 25 L. & HUM. BEHAV. 433 (2001)).

304. See Gatowski et al., *supra* note 303, at 452; see also Kittay, *supra* note 35, at 1397. “It is difficult to grasp how a proper *Daubert* inquiry can take place when 96% of state judges do not understand th[ese] benchmark criteri[a].” *Id.* at 1391. The *Daubert* court referred to falsifiability as a “key question.” *Daubert v. Merrell Dow Pharm.*, 509 U.S. 579, 593 (1993).

305. See McAuliff & Duckworth, *supra* note 296, at 489 (citing Margaret B. Kovera & Bradley D. McAuliff, *The Effects of Peer Review and Evidence Quality on Judge Evaluations of Psychological Science: Are Judges Effective Gatekeepers?*, 85 J. APPLIED PSYCHOL. 574 (2000)).

306. See Mara L. Merlino et al., *Judicial Gatekeeping and the Social Construction of the Admissibility of Expert Testimony*, 26 BEHAV. SCI. & LAW 200–02 (2008) (suggesting that some judges refuse to admit evidence simply because they have difficulty grasping its qualitative complexity). An alternative explanation that has been suggested is that judges assess scientific evidence with a sufficiency standard instead of a lower admissibility bar to evidence. See Michael D. Green & Joseph Sanders, *Admissibility Versus Sufficiency: Controlling the Quality of Expert Witness Testimony in the United States* (Wake Forest Univ. Legal Studies Paper No. 2016468; Univ. of Hous. Law Ctr. Paper No. 2016468, 2012), available at <http://ssrn.com/abstract=2016468>.

3. *No Problem: Jurors Are on the Same Page as Judges*

Ultimately, even though juries may get more verdicts objectively wrong than society would be comfortable with,³⁰⁷ jurors generally perform consistently well when assessed with external criteria of performance.³⁰⁸ One scholar suggests that juror competence should not be assessed on an absolute scale (that is, as compared to factual truth) or even to that of expert witnesses; competence is more properly assessed across different kinds of evidence, or compared to the competence of judges.³⁰⁹ Failure to completely comprehend trial evidence, even scientific or technical in nature, does not produce a significant departure from the assessments of judges in the same cases.³¹⁰ Even though deficiencies in understanding evidence are undesirable, they ultimately do not have a significant effect on verdicts.³¹¹

Often, attorneys and judges exacerbate the problem and confuse juries further with their explanations and jury instructions, respectively.³¹² Contrary to the popular notion of jurors, the less they understand about expert testimony, the *less* likely they are to be influenced by it.³¹³ In fact, one study shows that *judges* are more

307. See Cooper Ellenberg, *Lie Detection: A Changing of the Guard in the Quest for Truth in Court?*, 33 L. & PSYCHOL. REV. 139, 146 (2009) (citing Bruce D. Spencer, *Estimating the Accuracy of Jury Verdicts*, 4 J. EMPIRICAL LEGAL STUD. 305, 307 (2007)) (asserting that juries returned an objectively incorrect verdict one out of eight or nine times in a case study of 3500 trials from the 1950s).

308. See Neil Vidmar, *Expert Evidence, the Adversary System, and the Jury*, 95 AM. J. PUB. HEALTH (SUPP. 1) S137 (2005).

309. See Cecil et al., *supra* note 292, at 764.

310. See Ellenberg, *supra* note 307, at 146 n.93 (citing Spencer, *supra* note 307, at 307) (showing that judges agreed with juries in eighty percent of cases in a study on the accuracy of jury verdicts, as measured by judge-jury agreement even when the “correct” verdict is unknown); Hans, *supra* note 292, at 61 (“[W]hatever problems jurors have with comprehending trial evidence are not severe enough to produce outcomes that are distinctly different from the assessments of professionally trained judges across a range of cases.”).

311. See Cecil et al., *supra* note 292, at 764.

312. Hans, *supra* note 292, at 61 (citing Richard O. Lempert, *Civil Juries and Complex Cases: Taking Stock After Twelve Years*, in VERDICT: ASSESSING THE CIVIL JURY SYSTEM 181 (R. Litan ed., 1993)); Eugene Morgulis, *Juror Reactions to Scientific Testimony: Unique Challenges in Complex Mass Torts*, 15 B.U. J. SCI. & TECH. L. 252, 265 (2009) (asserting that since most lawyers cannot fully grasp the scientific concepts themselves, they “focus on hurting experts’ credibility, muddling the scientific issues and making it more difficult for the jury to evaluate the evidence”).

313. See Shari S. Diamond, *Beyond Fantasy and Nightmare: A Portrait of the Jury*, 54 BUFF. L. REV. 717, 747 (2006) (“When the expert’s lack of clarity prevents jurors from understanding the testimony, jurors who do not understand it are less likely to be influenced by it.”).

likely than jurors to defer to expert testimony, and are also more likely than jurors to convict defendants when given the same scientific evidence.³¹⁴ The notion that jurors do not comprehend expert testimony well, or blindly defer to experts, is inconsistent with a substantial body of empirical research on the subject.³¹⁵

4. *Paternalism*

Given that jurors are sufficiently capable of understanding expert testimony, excluding such testimony on the grounds that the confusion it would engender substantially outweighs the probative value of fMRI is too paternalistic to justify its exclusion.³¹⁶ In *Scheffer*, two Supreme Court Justices, Justices Stevens and Kennedy, even spoke out in defense of the average juror.³¹⁷ Excluding reliably probative evidence using evidentiary rules to “protect the ignorant jury” is becoming a relic of the past.³¹⁸

The apparent concern that jurors lose all sense of reality and simply believe anything and everything they see depicted on a television or computer screen presupposes a certain naiveté and basic lack of intelligence on the part of juries that is not only unwarranted as a matter of psychological research, but is also offensive and even elitist.³¹⁹

Evidence suggests that the best way to reduce jury confusion is to improve the clarity of both attorneys’ and experts’ explanations.³²⁰

314. See Valerie P. Hans, *Judges, Juries, and Scientific Evidence*, 16 J.L. & POL’Y 19, 43 & n.69 (2007) (comparing judge and juror responses after a mock trial conducted using mitochondrial DNA evidence).

315. See Vidmar, *supra* note 308, at S142; see also Vidmar & Diamond, *supra* note 304, at 1166–67.

316. See generally Sanders, *supra* note 294.

317. See *United States v. Scheffer*, 523 U.S. 303, 318–19 (1998) (Kennedy, J., concurring in part) (concluding that the argument that the jury will be unable to properly weigh lie detector evidence “demeans and mistakes the role and competence of jurors in deciding the factual question of guilt or innocence”); *id.* at 337 (Stevens, J., dissenting) (“[T]he reliance on a fear that the average jury is not able to assess the weight of this testimony reflects a distressing lack of confidence in the intelligence of the average American.”).

318. Jeffrey Bellin, *The Significance (if Any) for the Federal Criminal Justice System of Advances in Lie Detector Technology*, 80 TEMP. L. REV. 711, 722 (2007) (quoting *Lee v. Martinez*, 96 P.3d 291, 297 (N.M. 2004)) (asserting that evidentiary exclusion for the purposes of “protect[ing] the jury from its perceived ignorance is a relic of a receding era.”).

319. Galves, *supra* note 123, at 217–18 (footnotes omitted).

320. See *supra* note 312 and accompanying text.

5. *The Great Legal Engine: Cross-Examination*

Much of the clarity, or obfuscation, comes from the “greatest legal engine ever invented for the discovery of truth,” cross-examination.³²¹ There, attorneys attempt to expose inconsistencies, emphasize deficiencies in arguments, and reduce the effectiveness of lying.³²² Indeed, the *Daubert* Court itself emphasized the importance of cross-examination in this context.³²³

Vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence These conventional devices, rather than wholesale exclusion . . . are the appropriate safeguards where the basis of scientific testimony meets the standards of Rule 702.³²⁴

The drafters of FRE 702 were wary of overzealous trial court judges, warning that their “role as gatekeeper is not intended to serve as a replacement for the adversary system.”³²⁵ Several other variables diminish the over-reaching effect of expert witness testimony in the courtroom,³²⁶ including the “hired gun” effect³²⁷: the more biased an expert is in his testimony, the more likely a juror will substantially or completely discount it.³²⁸

Cross-examination would be important in the early days of fMRI’s admissibility in order to temper its effect. First, expert testimony would need to be introduced to explain the nature of the fMRI, the criteria used for scoring, and the background assumptions.³²⁹ Then,

321. *California v. Green*, 399 U.S. 149, 158 (1970) (quoting 5 J. WIGMORE, EVIDENCE § 1367 (3d ed. 1940)). *But see* Schauer, *supra* note 74, at 1195 (citing Jules Epstein, *The Great Engine that Couldn’t: Science, Mistaken Identifications, and the Limits of Cross-Examination*, 36 STETSON L. REV. 727, 774–82 (2007)) (asserting that cross-examination is not as effective as television writers and viewers believe).

322. Schauer, *supra* note 74, at 1194.

323. Bellin, *supra* note 318, at 721.

324. *Daubert v. Merrell Dow Pharm.*, 509 U.S. 579, 596 (1993).

325. FED. R. EVID. 702 advisory committee’s note (amended 2000).

326. Emily L. Foster, *Anchoring and the Expert Witness Testimony: Do Countervailing Forces Offset Anchoring Effects of Expert Witness Testimony?*, 77 TENN L. REV. 623, 625 (2010); Lieberman et al., *supra* note 286, at 52; *cf.* Lora M. Levett & Margaret B. Kovera, *The Effectiveness of Opposing Expert Witnesses for Educating Jurors About Unreliable Expert Evidence*, 32 L. & HUM. BEHAV. 363, 363 (2008) (asserting that competing expert witnesses caused a general skepticism toward all the evidence, regardless of its objective quality, instead of sensitizing mock jurors to methodological deficiencies in the evidence).

327. Schauer & Spellman, *supra* note 5, at 23 & n.82.

328. *Id.*

329. Keckler, *supra* note 1, at 538.

cross-examination or rival expert testimony would need to focus on potential issues such as the error rate, possible contamination, invalid assumptions, etc.³³⁰ This process would help expose the shortcomings of fMRI technology and educate the jurors at the same time.³³¹ The benefits of this process have already been highlighted within the context of fMRI imaging: researchers who claimed to have found a disproportionate effect of fMRI images conceded that informing test subjects of the technology's limitations practically eliminated its effect.³³² If, or when, the technology becomes reliable enough to satisfy FRE 702, the solution is not wholesale exclusion, but to allow the judicial system to properly run its course with the expectation that jurors ultimately decide its evidentiary value for themselves. The confusion created and perpetuated by attorneys, expert witnesses, and judges cannot be grounds for exclusion of sufficiently probative evidence.

D. Misleading the Jury: The Jurors Are Already Misled

Another factor against which the probative value of fMRI deception detection must be weighed is its potential to mislead the jury.³³³ Much like its potential for unfair prejudice, critics worry that jurors will abandon their own abilities and solely rely on evidence fMRI can provide. Determining the weight and credibility of testimony is thought to be the “province of the jury,” composed of jurors “presumed to be fitted for it by their natural intelligence and their practical knowledge of men and the ways of men.”³³⁴ Jurors may not, however, be properly endowed with the natural intelligence necessary for such a task: jurors have been shown to consistently

330. *Id.* at 538. See *supra* Part III.A for a discussion on various methodological problems that could be raised on cross-examination. On the absurdity of the assertion that fMRI technology cannot be cross-examined, see Galves, *supra* note 123, at 225 (stating that the objection that images cannot be cross-examined like a live witness should be overruled every time it is raised).

331. Cheryl Boudreau & Mathew D. McCubbins, *Competition in the Courtroom: When Does Expert Testimony Improve Jurors' Decisions?*, 6 J. EMPIRICAL LEGAL STUD. 793, 815 (2009) (“[The] back and forth that occurs between witnesses and lawyers during trials . . . [is] beneficial not only because [it] close[s] the sophistication gap, but also because of the way this closing of the sophistication gap occurs.”).

332. McCabe et al, *supra* note 183, at 575. “Questioning the validity of the fMRI evidence reduced the proportion of guilty verdicts rendered to the level of the control condition that was not presented with any evidence of lying.” *Id.* at 574. *But see* Michael et al., *supra* note 227.

333. FED R. EVID. 403.

334. *United States v. Scheffer*, 523 U.S. 303, 313 (1998) (plurality opinion) (citing *Aetna Life Ins. Co. v. Ward*, 140 U.S. 76, 88 (1891)).

make poor credibility assessments based on both behavioral cues and contextual information.³³⁵ As such, fMRI technology can assist jurors in making credibility assessments without replacing their role as ultimate arbiters of credibility judgment, as shown in the following sections.

1. *Credibility Assessment*

Research generally shows that humans are very poor at making credibility assessments, and detecting lies or liars.³³⁶ Even though humans are good at lying, we have serious difficulty discerning lies in others.³³⁷ An average person's ability to detect deception in a face-to-face interaction with another individual is only slightly better than chance.³³⁸ Despite intuitively having more interaction with deception, even those in law enforcement perform only slightly better than average people in the same tasks.³³⁹ Not only are humans bad at detecting deception, we have a false sense of confidence in our abilities, leading us to believe that we are better than we actually are.³⁴⁰ Generally, humans use "the demeanor of witnesses, their past record of truth telling, the internal coherence of their stories, and the external coherence of their stories with the stories of others" to assess witness credibility.³⁴¹

a. *Credibility Assessment Using Demeanor*

Social science indicates that laypeople poorly assess credibility when relying on behavioral cues, such as "facial expressions, tone of

335. See *infra* Part III.D.1 for a discussion on jurors' poor credibility assessment.

336. Seaman, *supra* note 3, at 435 n.36.

337. Langleben & Moriarty, *supra* note 8, at 223 (citing ALDERT VRIJ, *DETECTING LIES AND DECEIT: PITFALLS AND OPPORTUNITIES* (2d ed. 2008)).

338. *Id.* at 2 (citing Paul Ekman & Maureen O'Sullivan, *Who Can Catch A Liar?*, 46 AM. PSYCHOL. 913 (1991)); Schauer, *supra* note 74, at 1213 n.114 (citing various studies that place the ceiling of the ability of untrained people to determine truth telling in others around sixty percent).

339. Keckler, *supra* note 1, at 514 n.18 (citing Christian A. Meissner & Saul M. Kassin, "He's Guilty!": *Investigator Bias in Judgments of Truth and Deception*, 26 L. & HUM. BEHAV. 469, 472 (2002) (showing in a review of studies no effect of training, except increased likelihood of labeling all individuals as deceitful, yielding more Type II errors, along with increased false confidence in one's abilities)).

340. Seaman, *supra* note 3, at 435 n.36; see also Meixner, *supra* note 24, at 1465 (asserting that test subjects were "unable to discern how effectively they determined credibility based on demeanor evidence").

341. Schauer, *supra* note 74, at 1195 (citing James P. Timony, *Demeanor Credibility*, 49 CATH. U. L. REV. 903, 907-13 (2000)).

voice, aversion of gaze, and general nervousness.”³⁴² Instead, people are better able to detect deception when they can discern body language that subconsciously “leaks” information, which a liar would prefer to keep hidden.³⁴³ People assess the veracity of statements based on emotional cues at near chance accuracy.³⁴⁴ In one experiment, an attempt to train test subjects with a method that assists in discerning verbal and nonverbal cues to detect deception resulted in even *lower* accuracy and, despite that reduced accuracy, higher confidence than those not trained in the accuracy of their judgments.³⁴⁵ A meta-analysis of the most current research, which included results from over 24,000 people, found a fifty-four percent accuracy rate in assessing deception judgments.³⁴⁶

b. Credibility Assessment Using Context

Research also indicates that laypeople poorly assess credibility when relying on the “context, consistency, and depth of witnesses’ statements.”³⁴⁷ Allowing people to take personal biases and context into consideration marginally improves lie detection accuracy, but only in certain situations.³⁴⁸ Even allowing jurors to cross-check

342. Meixner, *supra* note 24, at 1452, 1463; Max Minzner, *Detecting Lies Using Demeanor, Bias, and Context*, 29 *CARDOZO L. REV.* 2557, 2565 (2008) (citing Bella M. DePaulo et al., *Cues to Deception*, 129 *PSYCHOL. BULL.* 74 (2003)) (“[F]ew reliable cues to deception exist and in particular, the cues widely believed by the public to signify deception generally do not.”).

343. Jeremy A. Blumenthal, *A Wipe of the Hands, a Lick of the Lips: The Validity of Demeanor Evidence in Assessing Witness Credibility*, 72 *NEB. L. REV.* 1157, 1201 (1993).

344. See Paul Ekman & Maureen O’Sullivan, *Who Can Catch a Liar?*, 46 *AM. PSYCHOL.* 913 (1991); see also Olin G. Wellborn III, *Demeanor*, 76 *CORNELL L. REV.* 1075, 1075 (1991) (“According to the empirical evidence, ordinary people cannot make effective use of demeanor in deciding whether to believe a witness. On the contrary, there is some evidence that the observation of demeanor diminishes rather than enhances the accuracy of credibility judgments.”). See generally Meixner, *supra* note 24 (describing this experiment in more depth).

345. See generally Saul M. Kissin & Christina T. Fong, *“I’m Innocent!”: Effects of Training on Judgments of Truth and Deception in the Interrogation Room*, 23 *LAW & HUM. BEHAV.* 499 (1999); see also Meixner, *supra* note 24, at 1464 n.99 (2012) (citing Kissin & Fong, *supra*, at 499).

346. Meixner, *supra* note 24, at 1466–67 (2012) (citing Charles F. Bond, Jr. & Bella M. DePaulo, *Accuracy of Deception Judgments*, 10 *PERSONALITY & SOC. PSYCHOL. REV.* 214, 216–17, 219 (2006)).

347. *Id.* at 1468.

348. Max Minzner, *Detecting Lies Using Demeanor, Bias, and Context*, 29 *CARDOZO L. REV.* 2557, 2568–78 (2008) (asserting that using contextual cues improves deception detection when in line with personal biases, while it reduces deception detection to under-chance accuracy when not in line with said biases).

stories by asking questions only marginally improved truth or lie detection accuracy.³⁴⁹ Assuming *arguendo* that there would be a marginal improvement if jurors were allowed to ask questions during trial, the most optimistic juror credibility studies find around sixty percent accuracy.³⁵⁰

IV. fMRI MAY CHANGE EVERYTHING, BUT FRE 403 CHANGES NOTHING

This Note proceeds on the very strong assumption that fMRI deception detection technology will improve to the point of satisfying *Daubert* and its accompanying case law. On one hand, jurors do not attribute more subjective weight than the objective value of fMRI images, which means that these images do not create unfair prejudice that outweigh their probative value. On the other hand, jurors currently overvalue strongly relied upon forensic evidence such as fingerprints and DNA. Justice Thomas's plurality opinion in *Scheffer* is ultimately non-binding on any court that will pass upon fMRI's admissibility.³⁵¹ Although once thought to be exclusively within the "province of the jury," empirical evidence shows that jurors are simply inept at making consistent and accurate credibility determinations.³⁵² Courts have several options that can dampen the potential negative impact of its admission, while its admission itself will serve to perfect the technology and its application.³⁵³ Ultimately, once this technology satisfies *Daubert*, FRE 403 will not be a bar to its admissibility.

A. fMRI Images Remain Innocent Until Proven Guilty

FRE 403 will not preclude the admissibility of fMRI deception detection because its resulting images do not create undue prejudice. Although of deep previous concern to many scholars,³⁵⁴ new evidence shows that jurors do not give disproportionate value to fMRI images;³⁵⁵ as such, they cannot be excluded under FRE 403 for creating undue prejudice that substantially outweighs its probative value. The question is *not* whether the fMRI images create prejudice,

349. Meixner, *supra* note 24, at 1468–74.

350. *Id.* at 1473 & n.143 (citing Maria Hartwig et al., *Detecting Deception via Strategic Disclosure of Evidence*, 29 LAW & HUM. BEHAV. 469, 477 (2005)).

351. *See infra* Part IV.C; *see also* United States v. Scheffer, 523 U.S. 303 (1998).

352. *See infra* Part IV.D.

353. *See infra* Parts IV.E, IV.F.

354. *See supra* notes 213–16 and accompanying text.

355. *See supra* notes 241–47 and accompanying text.

as creating prejudice by producing powerful enough evidence to convince a neutral third party of the persuasiveness of an argument is the foundation of our adversarial system.³⁵⁶ Rather, it is whether they are *falsely* powerful, in that they are more powerful than other types of visual evidence that the legal system consistently admits,³⁵⁷ and this disproportionate power is unjustifiable in relation to the evidence's reasonable objective value. Some scholars suggest that the admission of fMRI images would sacrifice procedural justice in favor of substantive justice.³⁵⁸ However, precluding fMRI images, despite their having no unique additional influence compared to other visual images³⁵⁹ or other neuroscientific evidence, that are both already routinely admissible,³⁶⁰ would sacrifice procedural justice owed to the images themselves. Despite developing sufficient reliability to satisfy *Daubert*, there may still be a problematic gap between its reliability and its ability: “[e]ven a test that is accurate enough to meet the *Daubert* standard will have serious implications for perceived systemic legitimacy if it is persuasive enough to yield a conviction without other strong supporting evidence but is not accurate enough to ensure that an innocent person is never misdiagnosed.”³⁶¹

356. Galves, *supra* note 123, at 222 (“[C]reating prejudice is exactly what an advocate is doing when she is advocating for her client or when a witness is testifying on behalf of one of the litigants—getting the jury to believe her side of the case and her version of the facts.”).

357. Schauer, *supra* note 83 (manuscript at 37–38) (“[The] precise question to be asked about fMRI evidence therefore, is . . . whether the inflated value they produce is greater than the inflated value produced by the visual evidence that the legal system routinely admits.”).

358. Meixner, *supra* note 24, at 1462 n.79 (discussing other potential goals of the justice system besides trial accuracy). “It is not clear whether this reduction in procedural justice would be worth the gain in trial accuracy, though one could argue that modern forensic science has the same problem yet continues to be admitted.” *Id.* at 1487; see also Sanders, *supra* note 294, at 940–41.

359. See, e.g., David Gruber & Jacob A. Dickerson, *Persuasive Images in Popular Science: Testing Judgments of Scientific Reasoning and Credibility*, 21 PUB. UNDERSTANDING SCI. 938 (2012) (conducting a study with results showing that there was no discernible impact between fMRI images and artistic renderings or science-fiction movie still shots depicting the brain). See generally Jewel, *supra* note 227 (discussing the advantages of visual advocacy).

360. See *supra* notes 234–36 and accompanying text (discussing how fMRI images added no additional impact as compared to neuropsychological testing results); see also Chloe Boyle, *Juror Perception of fMRI Evidence* (Sept. 14, 2011) (unpublished M.S. thesis, California State University, Fullerton) (on file with author) (comparing juror evaluation of conditions with the variables of fMRI imaging and accompanying expert testimony in a legal setting).

361. Meixner, *supra* note 24, at 1487. “Though truth and legitimacy are certainly distinct functions of the jury trial, legitimacy is closely tied to the system’s ability (real or apparent) to discover the truth.” Seaman, *supra* note 3, at 472 n.193. This

B. Jurors Overvalue Other Types of Evidence

The gap between the scientific reliability of evidence and the ability of such evidence to secure a criminal conviction may be inevitable,³⁶² as jurors often overvalue weak or unreliable types of evidence, such as eyewitness testimony and forensic evidence, which are heavily relied upon in securing wrongful convictions.³⁶³ Eyewitness testimony has been called the “single greatest cause of wrongful convictions” in this country.³⁶⁴ Some types of forensic evidence are routinely admitted despite the fact that they might not satisfy *Daubert* if their admissibility was decided for the first time today,³⁶⁵ and weak forensic evidence has led to a “disturbing number of convictions.”³⁶⁶ Yet, these weak types of evidence serve important functions in the law, and so too will fMRI deception detection technology once it satisfies the *Daubert* threshold.³⁶⁷

C. Justice Thomas’s *Scheffer* Opinion Is Not Binding

Indeed, Justice Thomas’s apprehension toward lie detection technology and the usurpation of the jury’s role in his *Scheffer* opinion applies to *all* expert testimony routinely admitted in court.³⁶⁸ As aforementioned, other types of evidence lend themselves to undeserved deference, yet jurors are still regularly, and

sentiment is traceable back to William Blackstone’s well-known maxim, “it is better that ten guilty persons escape, than that one innocent man suffer.” 4 WILLIAM BLACKSTONE, COMMENTARIES *358.

362. To the author’s knowledge, there is no published research on the reasoning underlying the gap between evidentiary reliability and overvaluation. It is possible that it is inevitable given the function of evolution and human cognitive heuristics, for example, to believe in eyewitness testimony.

363. *See supra* Part III.B.2.

364. *See supra* note 264 and accompanying text.

365. *See supra* note 271 and accompanying text.

366. *See supra* note 283 and accompanying text.

367. Schauer, *supra* note 74, at 1209 (“[W]eak (and thus potentially flawed) evidence serves important functions in law. Requiring highly valid scientific processes to certify evidence as ‘compelling,’ ‘conclusive,’ or even ‘highly reliable’ in order for that evidence to be usable would dramatically revamp the legal system as we know it.”).

368. Bellin, *supra* note 318, at 721 (asserting that once lie detection technology becomes reliable enough to pass the *Daubert* standard, the “residual danger that the jury will be misled or confused by a particular lie detector expert is then indistinguishable from that present with other scientific expert testimony routinely admitted”). “Justice Thomas’s distinction notwithstanding, the problem of deference to expert opinion is a problem for all expert testimony. There is no reason to believe that jurors will be less able to assess neuroscience evidence than they are to assess DNA evidence or any other scientific evidence.” Pardo, *supra* note 23, at 317.

fundamentally, trusted to assess such evidence for themselves.³⁶⁹ However, even though some scholars emphasize the superiority of fMRI deception detection's scientific reliability or validity over either polygraph technology³⁷⁰ or forensic science³⁷¹ as a basis for eventual admissibility, another scholar suggests that the assumption that courts admit these types of evidence because of their reliability may be unwarranted.³⁷² These other types of evidence will continue to be admitted because of their strong tradition of admissibility,³⁷³ but that same tradition should not also serve to keep fMRI deception detection technology out of the courtroom due simply to its superficial similarity to the polygraph as a lie detector.³⁷⁴

As far as Justice Thomas's "province of the jury" concern goes, the Court's decision in *Scheffer* does not preclude the admission of fMRI lie detection technology. As an opinion joined by only a plurality of the court, it has no binding precedential effect on future court decisions.³⁷⁵ The Court upheld the military's ban on the use of polygraph technology in court-martial proceedings on the narrow grounds of the government having a legitimate interest in doing so.³⁷⁶ The oft-quoted phrase of the case, "[a] fundamental premise of our criminal trial system is that 'the jury is the lie detector,'" lies within Justice Thomas's plurality opinion.³⁷⁷ Indeed, Justice Kennedy emphasized the court's narrow holding in his concurring opinion.³⁷⁸

369. Pardo, *supra* note 23, at 317–18.

370. See Teitcher, *supra* note 151.

371. See Kittay, *supra* note 35.

372. See Meixner, *supra* note 24, at 1480.

373. *Id.*

374. *Id.*; cf. Kittay, *supra* note 35, at 1389–95 (asserting that society's apprehension against "mind-reading" devices might serve to make fMRI deception detection inadmissible).

375. Bellin, *supra* note 318, at 719; see Michael L. Eber, *When the Dissent Creates the Law: Cross-Cutting Majorities and the Prediction Model of Precedent*, 58 EMORY L.J. 207 (2008) (asserting that majority opinions that combine a plurality and concurrence in the judgment do not create binding precedential value).

376. *United States v. Scheffer*, 523 U.S. 303, 309 (1998).

377. *Id.* at 313 (quoting *United States v. Barnard*, 490 F.2d 907, 912 (9th Cir. 1973)). Another frequently cited part of the opinion is "[d]etermining the weight and credibility of witness testimony, therefore, has long been held to be the 'part of every case [that] belongs to the jury, who are presumed to be fitted for it by their natural intelligence and their practical knowledge of men and the ways of men.'" *Id.* (quoting *Aetna Life Ins. Co. v. Ward*, 140 U.S. 76, 88 (1891)). Justice Thomas's plurality opinion was joined by Chief Justice Rehnquist and Justices Scalia and Souter. *Id.* at 305. For a discussion of the different opinions and resulting conclusions, see Seaman, *supra* note 3, at 462 & n.148.

378. *Scheffer*, 523 U.S. at 318 (Kennedy, J., concurring) (concurring in the judgment on the grounds that the per se military ban on polygraph evidence served a

Thus, *Scheffer* does not preclude lie detection technology of sufficient reliability from being admissible simply on the notion that it would affect the jury's assessment of witness credibility.³⁷⁹ The prospect of this technology reaching sufficient reliability ultimately "raises fundamental questions about the role of the jury in our . . . justice system[], and indeed about the purpose of the jury trial itself."³⁸⁰

D. The Jury Needs Whatever Help It Can Get

FRE 403 will not preclude the admissibility of fMRI deception detection because, instead of misleading the jury, it will provide a confused jury with much-needed assistance in making more accurate credibility assessments. Given the great difficulty jurors have with detecting lies,³⁸¹ fMRI deception detection technology will assist the jury's assessment of witness credibility without displacing its role as the ultimate arbiter of truth. The average ability to detect deception based on demeanor is around chance, with the use of contextual factors only marginally improving the ability to detect lies.³⁸² Once this technology improves, it will certainly assist in the juror's credibility assessment; however, introducing this technology will do anything but replace the jury.³⁸³ The notion of *truth* exists across a spectrum,³⁸⁴ and most objectively untrue statements uttered by trial witnesses are "mistakes, exaggerations, or distortions rather than bald-faced intentional lies."³⁸⁵ Further, as it stands, this technology

legitimate government interest); *see also* Bellin, *supra* note 318, at 719 (framing Justice Kennedy's opinion as holding that the "concern that polygraph evidence would erode the jury's role as primary or exclusive lie detector was a valid (i.e., not arbitrary) basis on which a policy maker could exclude such testimony").

379. Seaman, *supra* note 3, at 433 n.25 (citing 2 JOHN HENRY WIGMORE, A TREATISE ON THE ANGLO-AMERICAN SYSTEM OF EVIDENCE IN TRIALS AT COMMON LAW § 875 (2d ed. 1923)) (quoting Dean Wigmore) ("If there is ever devised a psychological test for the valuation of witnesses, the law will run to meet it."). *But see* Kittay, *supra* note 35, at 1353 (2007) (asserting that courts might bar admission of fMRI lie detection technology because of "society's suspicion and fear of 'mind reading' technologies"); Meixner, *supra* note 24, at 1460 ("Thus, even if a lie-detection tool achieved 100% accuracy when used in the hands of an expert, it would likely be precluded from use because it would 'invade the . . . province of the jury' and '[b]y its very nature . . . diminish the jury's role in making credibility determinations.'").

380. Seaman, *supra* note 3, at 434.

381. *See supra* Part III.D.

382. *See supra* Part III.D1.a.

383. *See* Seaman, *supra* note 3, at 475–78 (outlining the remaining role the jury will play in our justice system in light of the admission of fMRI lie detection technology).

384. *See supra* Part I.A.2.

385. Seaman, *supra* note 3, at 476.

cannot distinguish between true lies and false memories or assertions of subjective truth.³⁸⁶ A jury would need to assess other evidence presented that may override the test results, or prove to be more probative.³⁸⁷ The jury must also determine the credibility of the expert himself, assessing “bias, defects in test methodology, the reliability of the particular machinery used, or even outright corruption and deceit.”³⁸⁸

fMRI deception detection’s probative value will not be substantially outweighed by its potential to confuse the jury under FRE 403 because it is not intrinsically more confusing than other types of evidence, and confusion stemming from evidence may actually be caused by attorneys and judges. The difficulty jurors have with scientific evidence is shared by judges, which reminds us of the famous quote, “Democracy is the worst form of government, except for all those other forms that have been tried from time to time.”³⁸⁹ The right to a jury trial, with all of its faults, is a constitutional right and is here to stay for the foreseeable future.³⁹⁰ Deceptiveness “should be presented as probabilistic rather than a categorical conclusion that a given witness is truthful or deceptive.”³⁹¹ The statistical analysis required to produce the fMRI data and images, as well as this probabilistic conclusion of deceptiveness, may initially confuse the jury given its difficulty with mathematics.³⁹² Nevertheless, the solution for this confusion is not for the legal system to paternalistically exclude any evidence that has the propensity to confuse, as such paternalism undermines the intelligence of the average American.³⁹³ Rather, attorneys must enhance the clarity of their explanations.

386. *See id.* at 476 n.215.

387. Pardo, *supra* note 23, at 318.

388. Seaman, *supra* note 3, at 475.

389. Sir Winston Churchill, *Address Before House of Commons (Nov. 11, 1947)*, in 444 THE OFFICIAL REPORT, HOUSE OF COMMONS (5TH SERIES) 203, 206–07, available at <http://hansard.millbanksystems.com/commons/1947/nov/11/parliament-bill>.

390. U.S. CONST. amend. VI; *see also* Stronge, *supra* note 4, at 113 (noting the societal importance of the jury system as one that “enables society at large to be involved in the determination of guilt, and when mistakes are made, either by exonerating a guilty defendant or imprisoning an innocent one, society shares in the responsibility for this mistake”).

391. Langleben & Moriarty, *supra* note 8, at 227.

392. *See supra* notes 293–94 and accompanying text.

393. *United States v. Scheffer*, 523 U.S. 303, 337 (Stevens, J., dissenting) (“[T]he reliance on a fear that the average jury is not able to assess the weight of this testimony reflects a distressing lack of confidence in the intelligence of the average American.”).

E. Additional Suggestions to Lessen Potential Harmful Impacts of fMRI Deception Detection.

Scholars have presented additional suggestions to lessen any potential harmful impact that fMRI deception detection technology may have. Because jurors with more formal education or background in science and mathematics perform better in assessing scientific evidence,³⁹⁴ some scholars suggest conferring that benefit by neutrally training the jury through a short tutorial before the beginning of the trial.³⁹⁵ As mentioned in the advisory committee notes of FRE 403 itself,³⁹⁶ proper cautionary jury instructions may be fashioned for two reasons. First, they are created to remind jurors of the technical and legal limits of this technology,³⁹⁷ so that they do not overvalue or misapply the evidence produced.³⁹⁸ Second, to avoid the gatekeeper effect, jurors must understand that they are to assess the reliability and weight given to the evidence by virtue of the testimony given, and not the fact that it merely satisfies *Daubert*.³⁹⁹ Even more drastic recommendations include appointing special masters selected for their expertise in the subject matter to serve as expert witnesses,⁴⁰⁰ or a moratorium on all non-research uses of fMRI deception detection until a regulatory agency can assess the research and adopt field-wide standards.⁴⁰¹

F. The Admission of fMRI Will Only Improve Its Reliability

Ultimately, fMRI deception detection's reliability will only improve with its admission; with this increase in reliability,⁴⁰² the

394. Hans, *supra* note 292, at 69.

395. *Id.*; see also Schweitzer & Saks, *supra* note 293, at 433 (asserting that study results showed that “[t]rained jurors were better able to assess the quality of the research, and these more accurate assessments were reflected in their verdicts”).

396. FED. R. EVID. 403 advisory committee's note.

397. E. Spencer Compton, *Not Guilty by Reason of Neuroimaging: The Need for Cautionary Jury Instructions for Neuroscience Evidence in Criminal Trials*, 12 VAND. J. ENT. & TECH. L. 333, 346–54 (2010).

398. See Reese, *supra* note 2, at 205.

399. Schweitzer & Saks, *supra* note 2953, at 13.

400. *Id.*

401. Greely & Illes, *supra* note 52, at 413–21.

402. Seaman, *supra* note 3, at 460 n.134–35 (“Several scholars have observed that the judicial reaction against credibility expertise, and lie detection evidence in particular, has been wholly out of proportion to its purported lack of scientific reliability.”).

initial apprehension about fMRI will wane.⁴⁰³ If DNA, as the “gold standard” of evidence, provides a blueprint for the admissibility of fMRI deception detection, it might be at least another decade or two before the developmental gap between the theory and technology closes enough to reach a level of reliability and validity to be admissible in the judicial system.⁴⁰⁴ The challenges presented by the adversarial process through cross-examination or rival expert testimony will serve to refine the underlying process and presentation of this technique, as they did with DNA evidence.⁴⁰⁵ One scholar fears that seeking the admission of this technique too quickly might preclude its admission for the foreseeable future,⁴⁰⁶ which may mean it is already too late given the *Semrau* decision. It is more likely, however, that rejecting its admissibility will not be held to strict precedent, and will rather be reconsidered in light of the technique’s technological advancement.⁴⁰⁷

CONCLUSION

Once fMRI deception detection technology reaches a level of reliability sufficient enough to satisfy FRE 702 and *Daubert*, FRE 403 should not bar its admission. The images that fMRI deception detection techniques produce are not inherently overly prejudicial, and do not produce the ill-advised initial fear of a “Christmas tree effect.”⁴⁰⁸ fMRI images are no more influential than neuroscience evidence that has already been admissible for decades.⁴⁰⁹ It would be hypocritical to disallow fMRI deception detection evidence, yet routinely allow other types of evidence that are often unreliable, and

403. Pardo, *supra* note 23, at 312; *see, e.g.*, Jennifer L. Mnookin, *The Image of Truth: Photographic Evidence and the Power of Analogy*, 10 YALE J.L. & HUMAN. 1 (1998).

404. Law, *supra* note 86, at 57–58 (noting that there was a thirty-five-year gap between the discovery of the double-helix structure of DNA in 1953 and the first reported appellate court’s acceptance of a trial court’s admission of DNA-based evidence in 1988).

405. Keckler, *supra* note 1, at 538. This technology could also be initially limited to certain circumstances. *Id.* (noting that performing fMRI deception detection on a witness that has already proffered testimony negates any constitutional privacy and evidentiary hearsay issues).

406. Kittay, *supra* note 35, at 1396 (“Early rejections might not only stall, but doom the technology’s admissibility for years to come.”).

407. Feigenson, *supra* note 93, at 236 n.7 (asserting that advancing technologies should and would not be held to strict precedent given the improvements in the underlying technology).

408. *See supra* Part III.B.1.f (discussing the non-prejudicial effect of fMRI images).

409. *See supra* notes 234–36 and accompanying text (discussing how fMRI images added no additional impact as compared to neuropsychological testing results).

also often overvalued by the jury given their independent objective evidentiary value.⁴¹⁰ Lie detection evidence is not precluded from admission as a matter of *stare decisis*, given that Justice Thomas's plurality opinion in *Scheffer* has no binding precedential effect.⁴¹¹ Considering jurors' woeful credibility assessment abilities, they *need* the assistance that this technology will be able to provide.

Ultimately, this Note raises two issues that pervade discussions in the larger legal arena. First, this Note addresses what encapsulates the concept of evidentiary reliability, and how different standards of reliability may be applied to different types of evidence. Second, this Note addresses what the role of the jury, and the jury trial as a whole, is within our justice system. Many of the issues that scholars raise with regard to fMRI deception detection technology are not unique to this technique, which ultimately raises the following question: "Is expert evidence really different?"⁴¹² As a thought experiment goes, if (or when) lie detection technology were to reach perfect accuracy, would there be a role for the jury, or jury trial, whatsoever?⁴¹³ Would it even have to reach perfect accuracy, or would it simply have to be more accurate than the juries themselves? This technology may implicate issues that will cause problems at first,⁴¹⁴ but with the right protections and safeguards,⁴¹⁵ it will ultimately serve, and greatly benefit, society by delivering greater justice. In our justice system's search for objective truth, this technology will certainly only uncover more of it, which is a foundational purpose of our adversarial justice system. Precluding its admission would not only be an injustice to those that this technology could assist, from defendants to jurors, but it would also be an injustice to justice itself.

410. See *supra* Part III.B.2.

411. See *supra* Part IV.C.

412. See generally Schauer & Spellman, *supra* note 5.

413. In most of the recent experiments testing the overvaluation of fMRI images, test subjects were not told that the technology had any faults, and yet, the technology still did not have excessive influence. This may be a problem if, or when, the technology becomes very accurate. In other words, it would be a problem if the jury *should* value the evidence very highly, yet does not. In such a case, advocacy jury instructions or judgments N.O.V. might be appropriate.

414. This technology could also exacerbate effects of economic inequalities among defendants. See Adina L. Roskies et. al., *supra* note 220, at 100. Some argue that it would be easier for defendants to avoid convictions altogether. See, e.g., Schauer, *supra* note 74, at 1203-04 (quoting Michael H. Graham, *Burdens of Proof and Presumptions in Criminal Cases*, 45 CRIM. L. BULL. 192 (2009)) (asserting that it would be easier for defendant to avoid convictions since they only need "slight" evidence to escape the "beyond all reasonable doubt" standard); Teitcher, *supra* note 151.

415. See generally Shen, *supra* note 7 and accompanying text.