WEAVING FUNCTIONAL BRAIN IMAGING INTO THE TAPESTRY OF EVIDENCE: A CASE FOR FUNCTIONAL NEUROIMAGING IN FEDERAL CRIMINAL COURTS

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Recent advances in brain imaging technologies allow researchers to "peer inside" a defendant's brain. Although functional neuroimaging evidence is frequently used in civil litigation, federal courts have been hesitant to admit it into evidence in criminal trials. Scholars and commentators alike continue to debate the merits, detriments, and general admissibility of functional neuroimaging evidence in the criminal context. Meanwhile, federal judges repeatedly admit various forms of forensic science into evidence without evaluating them under the appropriate admissibility standards. This Note argues that this has created a double standard for evidence admissibility. Functional neuroimaging evidence may, in fact, be more scientifically reliable than some of the forensic science evidence currently admitted at trial. Accordingly, this Note proposes that judges should consider the disparity in evidentiary standards when considering the admissibility of functional neuroimaging evidence, and should carefully and fairly examine such evidence when proffered in federal criminal trials.

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INTRODUCTION

At approximately 2:30 PM on March 30, 1981, six shots were fired outside of the Washington Hilton Hotel. John Hinckley, Jr. attempted the assassination of President Ronald Reagan, wounding the President and three others.[1] During his trial fifteen months later, Hinckley's defense attorney called to the stand a radiologist who showed the jury a computer axial tomography (CAT) scan depicting atrophy of Hinckley's brain.[2] With the images projected on a screen in the courtroom, the doctor testified that the atrophy was abnormal, suggesting "organic brain disease,"[3] a term used to describe impaired mental functioning. Although the presiding judge initially barred the images from being displayed in the courtroom for fear that the jury might grant them too much weight, he later decided to allow the images because they might help give the jury "a complete picture" of the evidence bearing upon Hinckley's guilt.[4] Three weeks later, the jury found Hinckley not guilty by reason of insanity.[5]

Since the Hinckley trial, the use of neuroscience in the courtroom has drawn significant public attention. Although the potential uses for functional neuroimaging in the courtroom have increased dramatically,[6] actual use has not. Critics decry the use of neuroimaging as too nascent of a science and too prejudicial or unreliable to meet admissibility standards,[7] though some say it will meet admissibility standards in the near future.[8] Proponents argue that functional neuroimaging evidence has significant probative value and may even satisfy the federal evidentiary standard, and should be admitted.[9]

However, the debate surrounding the admissibility of functional neuroimaging evidence seems misguided, and critics have held neuroimaging evidence to unusually restrictive admissibility standards.[10] At the very least, the admissibility standards have been applied to functional neuroimaging evidence more strictly than they have been applied to other forensic evidence offered in criminal trials.[11] As the evidentiary

1. Howell Raines, *Reagan Wounded in Chest by Gunman; Outlook 'Good' After 2-Hour Surgery; Aide and 2 Guards Shot; Suspect Held*, N.Y. TIMES, Mar. 31, 1981, at A1.

2. *See* Stuart Taylor, Jr., *CAT Scans Said to Show Shrunken Hinckley Brain*, N.Y. TIMES, June 2, 1982, at D19.

3. *Id.*

4. *Id.*

5. Stuart Taylor, Jr., *Hinckley Cleared but Is Held Insane in Reagan Attack*, N.Y. TIMES, June 22, 1982, at A1.

6. *See generally* Henry T. Greely, *Law and the Revolution in Neuroscience: An Early Look at the Field*, 42 AKRON L. REV. 687 (2009) (describing numerous legal applications and implications of the latest brain imaging technologies); David M. Eagleman, *Neuroscience and the Law*, HOUS. LAW., Mar.–Apr. 2008, at 37, 37–40 (same); *infra* Part I.B.2.

7. *See infra* Part II.A.

8. *See, e.g.*, Michael S. Pardo, *Neuroscience Evidence, Legal Culture, and Criminal Procedure*, 33 AM. J. CRIM. L. 301, 337 (2006); Laurence R. Tancredi & Jonathan D. Brodie, *The Brain and Behavior: Limitations in the Legal Use of Functional Magnetic Resonance Imaging*, 33 AM. J.L. & MED. 271, 291–93 (2007).

9. *See infra* Part II.B.

10. *See infra* Part II.B.2.

11. *See infra* Part I.D.4.

maxim goes: "A brick is not a wall,"[12] meaning that an item of evidence is relevant to the overall structure of the evidence but is not in itself the basis of all the evidence. Accordingly, judges should view functional neuroimaging as an evaluative tool, one of many bricks used to build the tower of evidence. This would provide litigants with the tools necessary to fully present and effectively argue their case and would allow juries to evaluate and consider useful functional neuroimaging evidence during the course of a trial.[13] After all, the purpose of scientific evidence is to elucidate the facts by providing the fact-finder with all relevant information to arrive at the truth,[14] and functional neuroimaging likely can aid in that endeavor.[15] Moreover, much of the scientific evidence currently admitted in criminal trials—specifically, forensic individualization sciences—is unreliable at best and dismal at worst.[16] Yet despite the scientific flaws and unreliability, courts often admit such evidence, and sometimes by judicial notice, without ever analyzing the evidence under the federal standard for admissibility.[17] Much of forensic individualization evidence has little, if any, scientific basis, but is often admitted based on a history of admission[18] in lieu of evidentiary merits.[19] Furthermore, admissibility challenges are largely biased in favor of the prosecution.[20]

Judges should strongly consider admitting functional neuroimaging evidence to balance the spectrum of evidence presented at trial and restore a fair adversarial process. Of course, proper safeguards such as carefully crafted jury instructions[21] should be instituted and maintained to prevent

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12. *See* CHARLES T. MCCORMICK, MCCORMICK ON EVIDENCE 339 (John W. Strong ed., abr. 4th ed. 1992) (describing the threshold for relevant evidence as low and that to be relevant, evidence only needs to make a determination of the fact in question more or less probable than it would be without the evidence).

13. *See* Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 589 (1993) ("'The Rules [of Evidence] were designed to depend primarily upon lawyer-adversaries and sensible triers of fact to evaluate conflicts.'" (quoting Jack Weinstein, *Rule 702 of the Federal Rules of Evidence Is Sound; It Should Not Be Amended*, 138 F.R.D. 631, 631 (1991))).

14. *Id.*

15. *See* Paul S. Appelbaum, *The New Lie Detectors: Neuroscience, Deception, and the Courts*, 58 PSYCHIATRIC SERVICES 460, 461 (2007) (arguing that judges must consider other factors in addition to whether neuroscientific evidence passes the *Daubert* test, specifically, "whether [the evidence] is likely to help the judge or jury resolve the legal issue in question").

16. *See infra* Parts I.D.1, I.D.3.

17. *See* Jane Campbell Moriarty & Michael J. Saks, *Forensic Science: Grand Goals, Tragic Flaws, and Judicial Gatekeeping*, 44 JUDGES' J., Fall 2005, at 16, 17, 29 (lamenting that forensic sciences are notoriously unreliable yet rarely questioned under *Daubert* standards); *infra* Part I.D.4, notes 223–25 and accompanying text.

18. This can be called an "evidentiary pedigree." *See infra* notes 251–61 and accompanying text.

19. *See infra* notes 224, 249–65 and accompanying text.

20. *See infra* notes 192, 234–37 and accompanying text.

21. *See* United States v. Williams, 583 F.2d 1194, 1200 & n.13 (2d Cir. 1978) (describing jury instructions, which stated that the forensic evidence presented at trial was for the jury's "assistance only and could be rejected if found unreliable"); United States v. Starzecpyzel, 880 F. Supp. 1027, 1049 (S.D.N.Y. 1995) (finding that narrowly tailored jury instructions could adequately address concerns that admitting forensic handwriting evidence would unfairly prejudice the jury); Moriarty & Saks, *supra* note 17, at 31; Michael J. Saks,

undue reliance on neuroimaging evidence, and independent external regulatory entities should be established to supervise imaging methodologies and govern their courtroom use.[22] Even when no forensic individualization evidence is offered, judges should consider admitting the evidence to avoid a double standard for admitting scientific evidence.[23] This would ensure that the fact-finders—both juries and judges alike—have the information necessary to help them arrive at a decision on the legal issue at hand while using appropriate safeguards to narrow the scope of functional neuroimaging evidence.[24]

Much has been written about neuroscience evidence admissibility in general,[25] but no work known to this author examines neuroscience evidence in light of forensic individualization evidence. Doing so would help guide judges on how to handle functional neuroimaging evidence to maintain a fair and balanced adversarial system. As brain imaging technology continues to improve, attempts to admit functional neuroimaging evidence in criminal trials will likely increase. Especially in light of a recent governmental report addressing the significant shortfalls of forensic sciences and its continued use in the courtroom,[26] judges should reassess their reluctance to admit functional neuroimaging into evidence in criminal trials.

Part I of this Note introduces the reader to brain imaging in general and describes neuroscience's impact on the law. Part I.B discusses functional neuroimaging, its numerous methodologies, and how it can be used in the courtroom. Part I.C briefly surveys the federal admissibility standards for scientific expert testimony, which governs functional neuroimaging evidence. Because this Note focuses on applications of functional neuroimaging to criminal law in federal cases, Part I.D discusses how the

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Protecting Factfinders from Being Overly Misled, While Still Admitting Weakly Supported Forensic Science into Evidence, 43 TULSA L. REV. 609, 625 (2007) (suggesting that the problem of misleading a jury with weak forensic evidence can be "ameliorated somewhat" by appropriate jury instructions); E. Spencer Compton, Note, *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, 347–50 (2010) (arguing that careful jury instructions should be used when dealing with neuroscience-based evidence).

22. *See* Laura Stephens Khoshbin & Shahram Khoshbin, *Imaging the Mind, Minding the Image: An Historical Introduction to Brain Imaging and the Law*, 33 AM. J.L. & MED. 171, 190–92 (2007).

23. Both functional neuroimaging and forensic individualization are types of scientific evidence that should be subject to identical evidentiary standards. *See infra* notes 219–22 and accompanying text.

24. *See Starzecpyzel*, 880 F. Supp. at 1049 (noting that the jury is fully capable of ignoring unhelpful evidence in its deliberations, and respecting the jury's ability to do so); *see also* Appelbaum, *supra* note 15, at 461 (noting the jury is the ultimate arbiter of the truth).

25. The MacArthur Foundation Research Network on Law and Neuroscience has compiled, and continues to update, an exhaustive annotated bibliography of past and current literature on the subject of neuroscience and the law. *See Law and Neuroscience Bibliography*, MACARTHUR FOUNDATION RESEARCH NETWORK ON LAW & NEUROSCIENCE, http://www.lawneuro.org/bibliography.php (last visited Sept. 21, 2011).

26. *See infra* Part I.D.3–4.

federal admissibility standards are currently applied to a foundational aspect of criminal law evidence: forensic individualization sciences.

Part II outlines the arguments both in favor and against admitting functional neuroimaging as evidence. This part includes arguments about the evidence's reliability, relevance, utility, and its potential to mislead, confuse, or prejudice the jury. Part II also illustrates how functional neuroimaging is currently analyzed under federal evidentiary standards by federal criminal courts.

Part III suggests that judges should carefully consider admitting functional neuroimaging evidence when offered in criminal trials, especially in light of the quality of forensic evidence currently used in such cases. This Note concludes by suggesting that although functional neuroimaging evidence likely should be admissible, a governing body should be created to establish guidelines to regulate its use.

I. NEUROSCIENCE AND THE EVIDENCE ADMISSIBILITY STANDARDS

A. Structural and Anatomical Brain Imaging and Its Impact on the Law

Neuroimaging technology is not new. The first images of the brain appeared in the early part of the twentieth century,[27] and, with the advent of computerized tomography (CT), brain imaging technology rapidly progressed as a full-fledged science in the early 1970s.[28] Technological advancements soon led to the development of nuclear magnetic resonance (NMR) imaging, known as "magnetic resonance imaging" (MRI).[29] With the ability to produce exquisitely precise anatomic detail, MRI soon became the preferred method for imaging the brain.[30]

MRI and other imaging technologies, such as positron emission tomography (PET), electroencephalography (EEG), and single photon emission computed tomography (SPECT), soon led to functional imaging of the brain.[31] By the 1990s, neuroscience in general and neuroimaging technologies in particular underwent such unprecedented growth that President George H.W. Bush officially proclaimed the 1990s the "Decade of the Brain."[32]

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27. Erin D. Bigler, *Introduction* to NEUROIMAGING I: BASIC SCIENCE 1, 1 (Erin D. Bigler ed., 1996).

28. *Id.* at 2.

29. *Id.*

30. *Id.*; Duane D. Blatter et al., *A Normative Database from Magnetic Resonance Imaging*, *in* NEUROIMAGING I: BASIC SCIENCE, *supra* note 27, at 79 ("Without controversy, magnetic resonance (MR) imaging achieves exquisite approximation of gross anatomy.").

31. *See* Bigler, *supra* note 27, at 2. As opposed to structural brain imaging, functional brain imaging allows neuroscientists to "peer inside" the living, working brain to detect specific patterns of brain activation. Doing so provides insight into how the brain operates. *See* ANDREW C. PAPANICOLAOU, FUNDAMENTALS OF FUNCTIONAL BRAIN IMAGING: A GUIDE TO THE METHODS AND THEIR APPLICATIONS TO PSYCHOLOGY AND BEHAVIORAL NEUROSCIENCE 5 (1998). This Note briefly reviews these technologies in Part I.B.1.

32. Proclamation No. 6158, 55 Fed. Reg. 29,553 (July 20, 1990).

Structural and anatomical brain imaging is currently used for diagnostic and investigative purposes, such as detecting brain lesions and improving the diagnosis and treatment of neurological diseases.[33] It has also impacted the legal system's understanding of criminal responsibility. Consider the case of Ron, a schoolteacher from Virginia.[34] For forty years, Ron led a conventional lifestyle without showing any signs of deviant behavior.[35] Inexplicably, once he turned forty, Ron developed a keen interest in child pornography and was subsequently arrested and convicted for making sexual advances toward his stepdaughter.[36] He was remanded to a rehabilitation clinic for sex offenders but was soon expelled because he was unable to control his urges, propositioning everyone with whom he came into contact.[37] The day before Ron was scheduled to appear before the court for sentencing, he admitted himself to the emergency room complaining of a terrible headache.[38] Ron told his doctors that he was afraid he would rape his landlady and that he was unable to control himself.[39] Eventually, the doctors ordered a brain MRI. What they found shocked them. Ron had a tumor the size of an egg pressing against the right frontal lobe of his brain.[40]

After surgeons removed the tumor, Ron lost his uncontrollable urges and his pedophilia, and he easily completed his rehabilitation program.[41] He even moved back in with his wife and stepdaughter.[42] Seven months later, his chronic headaches returned, and he secretly began collecting pornography.[43] Another brain scan revealed that Ron's tumor had partially grown back.[44] A second surgical procedure successfully removed the tumor and relieved him of his urges.[45]

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33. *See* Purvak Patel et al., *The Role of Imaging in United States Courtrooms*, 17 NEUROIMAGING CLINICS N. AM. 557, 557 (2007).

34. *See* Lewis Barker, *Biological Psychology*, *in* 2 21ST CENTURY PSYCHOLOGY: A REFERENCE HANDBOOK 114, 114 (Stephen F. Davis & William Buskist eds., 2008); *Doctors Say Pedophile Lost Urge After Brain Tumor Removed*, USA TODAY (July 28, 2003, 6:46 AM), http://www.usatoday.com/news/health/2003-07-28-pedophile-tumor_x.htm.

35. Greely, *supra* note 6, at 700.

36. *Id.*

37. *Id.*

38. *Id.*

39. SANDRA AAMODT & SAM WANG, WELCOME TO YOUR BRAIN: WHY YOU LOSE YOUR CAR KEYS BUT NEVER FORGET HOW TO DRIVE AND OTHER PUZZLES OF EVERYDAY LIFE 174 (2008).

40. USA TODAY, *supra* note 34. The frontal lobe is known to regulate impulsive behavior. Damage to the prefrontal cortex is associated with disinhibition, antisocial behavior, and greater proclivity to break the law. *See* Robert M. Sapolsky, *The Frontal Cortex and the Criminal Justice System*, *in* LAW & THE BRAIN 227, 233–34, 237–38 (Semir Zeki & Oliver Goodenough eds., 2006); Liane Young et al., *Damage to Ventromedial Prefrontal Cortex Impairs Judgment of Harmful Intent*, 65 NEURON 845, 845 (2010).

41. Greely, *supra* note 6, at 701; USA TODAY, *supra* note 34.

42. USA TODAY, *supra* note 34.

43. Greely, *supra* note 6, at 701.

44. USA TODAY, *supra* note 34.

45. *Id.* Many other case studies describe how frontal lobe damage severely impacted an individual's behavior. *See, e.g.*, Joseph H. Baskin et al., *Is a Picture Worth a Thousand Words? Neuroimaging in the Courtroom*, 33 AM. J.L. & MED. 239, 250–63 (2007);

Ron's case illustrates how brain imaging can and does impact societal perceptions of criminal responsibility. If not for the egg-sized tumor pressing against his brain, Ron most likely would have been incarcerated for his "moral failing."[46] Instead, when the MRI revealed the tumor in his brain, Ron received a second chance and escaped prosecution even though he broke the law.[47] A case like Ron's challenges conventional notions of criminal responsibility for offenders with demonstrated physical abrasions or defects in the brain. Although brain tumors do not conclusively cause immoral behavior or make one unable to abide by the law,[48] a causal relationship is likely.[49] This is especially true when a physical abrasion or tumor such as Ron's afflicts an individual.[50] However, admitting evidence of brain damage or dysfunction absent any physical or "external" factor[51] is more problematic. It is in this context that functional brain imaging enters the discussion.

B. Functional Brain Imaging and Its Impact on the Law

Functional brain imaging is used frequently in cognitive neuroscience, which is "the field of scientific endeavor that is trying to understand how the brain enables the mind."[52] As brain imaging technologies progress, cognitive neuroscientists use functional brain imaging to study the human brain in action.[53] This provides doctors and scientists with the tools to help

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O. Carter Snead, *Neuroimaging and the "Complexity" of Capital Punishment*, 82 N.Y.U. L. REV. 1265, 1295–96 (2007).

46. Barker, *supra* note 34, at 114.

47. *See* Greely, *supra* note 6, at 701. In Virginia, making sexual advances toward a minor is a felony, as is possession of child pornography. VA. CODE ANN. § 18.2-370(A) (2010) (sexual advances toward minors); § 18.2-374.1:1(A) (possession of child pornography).

48. *See* Yaling Yang et al., *Brain Abnormalities in Antisocial Individuals: Implications for the Law*, 26 BEHAV. SCI. & L. 65, 74 (2008) ("[T]he causal relationship between structural/functional deficits and antisocial behavior remains unclear.").

49. *See, e.g.*, Sapolsky, *supra* note 40, at 239 ("What the literature about the [prefrontal cortex] shows is that there is a reductive, materialistic neurobiology to the containment, resulting in the potential for volitional control to be impaired just as unambiguously as any other aspect of brain function. It is possible to know the difference between right and wrong but, for reasons of organic impairment, to not be able to do the right thing.").

50. *See, e.g.*, Young et al., *supra* note 40, at 845–46 (finding that patients with lesions in their ventromedial prefrontal cortex—understood to be an essential moral-processing center in the brain—have difficulty delivering normal moral judgments and instead view attempted harms as morally permissible); *see also* Fairchild v. Workman, 579 F.3d 1134, 1150–51 (10th Cir. 2009) (suggesting that if the defendant's lawyer had presented the jury with evidence of physical brain damage as a partial explanation for the defendant's crime, it "could have provided an important explanation for the jury").

51. *See* Greely, *supra* note 6, at 701 (suggesting that a brain tumor may be considered an "external cause" even though it is inside one's skull).

52. Michael S. Gazzaniga, *What Is Cognitive Neuroscience?*, *in* A JUDGE'S GUIDE TO NEUROSCIENCE: A CONCISE INTRODUCTION 2, 2 (Andrew S. Mansfield ed., 2010) [hereinafter A JUDGE'S GUIDE].

53. *Id.* at 3.

them diagnose brain damage or disease when physical damage is absent.[54] But as critics of functional brain imaging point out, the results of these scans are not entirely dispositive—a causal relationship between specific brain functionality and criminal behavior has not yet been definitively determined.[55] The problem is less pressing when the results of functional brain scans are coupled with results indicating structural brain damage.[56] Nevertheless, functional brain imaging can significantly impact the law in its own right.[57]

1. Methods of Functional Brain Imaging

Functional neuroimaging helps scientists understand brain activity by measuring various biochemical and physiological events occurring within the brain.[58] Specifically, scientists measure the rate and volume of blood flow in areas of the brain involved in specific aspects of cognitive functioning and the rate of oxygen consumption in those areas (called a hemodynamic response),[59] or changes in various electrical currents.[60] While structural imaging captures a snapshot of the brain at one point in time, functional imaging tracks patterns of metabolic activity in the brain over a period of time.[61] Functional brain imaging is thus categorically different than structural brain imaging.

Generally, functional brain scans operate as follows: a subject is presented with a situation or performs a specific task, and researchers record the changes in the subject's brain activity as the subject responds or performs the task. Because the changes in brain activity are usually localized and occur over a measurable span of time, the scans yield spatio-temporal brain data.[62] The data is then compared with statistical maps of

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54. *See* 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, 1127–28 (2010).

55. *See* MICHAEL S. GAZZANIGA, THE ETHICAL BRAIN 87–102 (2005); Lydia D. Johnson, *Guilty or Innocent? . . . Just Take a Look at My Brain—Analyzing the Nexus Between Traumatic Brain Injury and Criminal Responsibility*, 37 S.U. L. REV. 25, 30–32 (2009); Stephen J. Morse, *Moral and Legal Responsibility and the New Neuroscience*, *in* NEUROETHICS: DEFINING THE ISSUES IN THEORY, PRACTICE, AND POLICY 33, 33–34 (Judy Illes ed., 2006) [hereinafter NEUROETHICS]; *infra* notes 298–305 and accompanying text.

56. *See, e.g.*, Fulks v. United States, No. 4:02-992, 2010 WL 3069390, at *16 (D. S.C. Aug. 3, 2010) (quoting a neuroscientist who testified that abnormalities in both brain structure and function "explain a lot of the behaviors, and the cognitive and emotional deficits" of the defendant).

57. *See generally* LAW, MIND AND BRAIN (Michael Freeman & Oliver R. Goodenough eds., 2009); Oliver R. Goodenough & Micaela Tucker, *Law and Cognitive Neuroscience*, 6 ANN. REV. L. SOC. SCI. 61 (2010); Read Montague, *How Is Neuroscience Likely to Impact Law in the Near Future?*, *in* A JUDGE'S GUIDE, *supra* note 52, 60, 60–65; Adina Roskies, *How Is Neuroscience Likely to Impact the Law in the Long Run?*, *in* A JUDGE'S GUIDE, *supra* note 52, at 66, 66–70.

58. *See* PAPANICOLAOU, *supra* note 31, at xi–xii.

59. Snead, *supra* note 45, at 1285.

60. *See* PAPANICOLAOU, *supra* note 31, at 5.

61. *See id.* at 4–6.

62. Owen D. Jones et al., *Brain Imaging for Legal Thinkers: A Guide for the Perplexed*, 2009 STAN. TECH. L. REV. 5, ¶ 18.

"normal" brain activity[63] or the subject's own baseline brain activity[64] by subtracting the normal or baseline reading from the data obtained from the experimental scan.[65] The varying degrees of statistically significant metabolic change are color coded to identify easily and differentiate between levels of activity.[66] This technique identifies areas of the brain engaged in specific mental tasks.[67] What follows is a brief overview of the various methods of functional brain imaging, including PET, SPECT, EEG, quantitative electroencephalography (qEEG), functional magnetic resonance imaging (fMRI), Brain Fingerprinting (BF), and finally, Brain Electrical Oscillations Signature Test (BEOS).

a. Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT)

PET and SPECT are older methods of functional brain imaging than the fMRIs of today.[68] For PET and SPECT scans, the subject is injected with organic, radioactive molecules called tracers, which are then dispersed throughout the brain according to metabolic need.[69] When metabolized, the molecules emit gamma rays, which are then detected and interpreted by computers and used to construct three-dimensional models of the working brain.[70] Researchers can use the data from multiple readings collected over a brief time span to determine which areas of the brain are involved in different types of brain activity with a high degree of specificity.[71] Because PET scans measure localized blood volume in specific tissues, they effectively detect nuanced characteristics of specific neurodegenerative diseases.[72]

Like PET, SPECT requires injecting radioactive tracers into the subject's bloodstream. The radioactive isotopes have longer half-lives, allowing SPECT scans to generate images for longer periods of time while exposing

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63. Donald Reeves et al., *Limitations of Brain Imaging in Forensic Psychiatry*, 31 J. AM. ACAD. PSYCHIATRY L. 89, 90 (2003) ("Statistical maps of brain activity are a common and popular way to illustrate how an individual brain compares with an average brain. A statistical map is a probability function compared with a defined norm. In brain imaging, the norm is obtained by pooling and averaging the brain images of normal people." (citation omitted)).

64. *See* PAPANICOLAOU, *supra* note 31, at 6–9.

65. *Id.*; Brown & Murphy, *supra* note 54, at 1136 n.63.

66. Brown & Murphy, *supra* note 54, at 1136 n.63; Jones et al., *supra* note 62, ¶ 34. By convention, brighter colors are used to depict differences in activity that are more statistically significant.

67. Jones et al., *supra* note 62, ¶ 13.

68. PAPANICOLAOU, *supra* note 31, at 66 (describing PET scans); Brown & Murphy, *supra* note 54, at 1136 (describing PET and SPECT as older scan methods).

69. PANANICOLAOU, *supra* note 31, at 67. Areas of the brain that are used more intensely have higher metabolic rates. *Id.*

70. Brown & Murphy, *supra* note 54, at 1136.

71. Jane Campbell Moriarty, *Flickering Admissibility: Neuroimaging Evidence in the U.S. Courts*, 26 BEHAV. SCI. & L. 29, 31–32 (2008).

72. Noel Shafi, *Neuroscience and the Law: The Evidentiary Value of Brain Imaging*, 11 GRADUATE STUDENT J. PSYCHOL. 27, 34 (2009).

the subject to fewer injections than a PET scan.[73] The tradeoff, however, is that SPECT does not map activity to specific brain areas as accurately as PET scans.[74]

Both PET and SPECT require injecting dangerous radioactive material into human subjects. This prevents multiple trials over a short period of time and thus diminishes the potential accuracy of the collected data.[75] Furthermore, PET and SPECT are also often prohibitively expensive, leading many researchers to use other less costly—and less dangerous—techniques.[76]

b. Electroencephalography (EEG)

Unlike PET and SPECT, EEG does not measure changes in blood flow in the brain, nor does it measure metabolic rate. Instead, it records the electrical current produced by brain activity measured via electrodes attached to the subject's scalp.[77] However, EEG can only record electrical activity occurring near the scalp and cannot probe deeper into the depths of the skull and brain.[78] It therefore lacks the spatial resolution and specificity of PET and SPECT, but has better temporal resolution, meaning it is better at detecting the nuanced timing differences of measured brain activity.[79]

c. Quantitative Electroencephalography (qEEG)

qEEG is a computer-based method for interpreting EEGs.[80] Digitized recordings of EEGs pass through a series of signal processing algorithms and are classified as normal or abnormal based on numerous factors such as frequency, events, or localization.[81] qEEG can also identify specific patterns of electrical activity associated with brain diseases or neurological disorders, such as slow brain waves associated with dementia.[82] While qEEGs have the added analytical component and power of a computer processor, the recording mechanism is still an EEG and thus has the same temporal superiority and spatial deficiency.

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73. Moriarty, *supra* note 71, at 32.
74. Mark Pettit, Jr., *FMRI and BF Meet FRE: Brain Imaging and the Federal Rules of Evidence*, 33 AM. J.L. & MED. 319, 320 (2007).
75. *See* Snead, *supra* note 45, at 1284.
76. *Id.*
77. Brown & Murphy, *supra* note 54, at 1136.
78. *Id.* at 1137.
79. *Id.* at 1136–37.
80. Scott T. Grafton, *Has Neuroscience Already Appeared in the Courtroom?*, *in* A JUDGE'S GUIDE, *supra* note 52, at 54, 55.
81. *Id.*
82. *Id.*

d. Functional Magnetic Resonance Imaging (fMRI)

The most prevalent method of functional brain imaging is fMRI.[83] The scan detects hemodynamic changes in different areas of the brain.[84] The amount of blood present in and flowing to a particular brain region, and the amount of oxygen present in that blood, depends on the level and intensity of brain activity occurring in that particular region of the brain.[85] Researchers interpret increased blood flow as an increase in that region's cellular activity.[86] In other words, if a particular set of neurons increases in activity, so will its metabolic rate. Like its structural and anatomical counterpart,[87] fMRI is widely accepted and broadly used for medical and research purposes.[88]

This method has two major advantages over other forms of functional neuroimaging. First, fMRI has much better spatial and temporal resolution than both PET and SPECT, usually on the order of millimeters and seconds.[89] The brain's hemodynamic response rises and falls over a period of a few seconds, yet fMRI can measure latency differences as small as a few hundred milliseconds.[90] Although the temporal resolution of fMRI is somewhat inferior to EEG and qEEG, its spatial resolution is far superior. Of the available neuroimaging techniques, scholars and researchers alike consider fMRI to provide the best balance of temporal and spatial resolution,[91] and the technology continues to improve.[92] Second, unlike PET and SPECT, fMRI is noninvasive since it does not require injecting radioactive isotopes into subjects.[93] Researchers can therefore conduct

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83. Snead, *supra* note 45, at 1284.

84. PAPANICOLAOU, *supra* note 31, at 47–49.

85. *Id.*; John C. Gore, *Principles and Practice of Functional MRI of the Human Brain*, 112 J. CLINICAL INVESTIGATION 4, 4–5 (2003).

86. Technically speaking, levels of oxygenated hemoglobin in the blood in specific brain areas decrease compared to the levels of deoxygenated hemoglobin in the same area. PAPANICOLAOU, *supra* note 31, at 48; Snead, *supra* note 45, at 1285.

87. *See supra* note 33 and accompanying text (describing medical and research uses of MRI).

88. *See* Brown & Murphy, *supra* note 54, at 1127–28; Marcus Raichlie, *What Is an fMRI?*, *in* A JUDGE'S GUIDE, *supra* note 52, at 5, 6 ("A recent check on the number of scientific publications in which fMRI . . . imaging was used revealed over twelve thousand publications since its introduction in 1992.").

89. Neal Feigenson, *Brain Imaging and Courtroom Evidence: On the Admissibility and Persuasiveness of fMRI*, *in* LAW, MIND AND BRAIN, *supra* note 57, at 23, 24; Snead, *supra* note 45, at 1284.

90. Henry T. Greely & Judy Illes, *Neuroscience-Based Lie Detection: The Urgent Need for Regulation*, 33 AM. J.L. & MED. 377, 382 (2007).

91. Judy Illes & Eric Racine, *Imaging or Imagining? A Neuroethics Challenge Informed by Genetics*, AM. J. BIOETHICS, Mar.–Apr. 2005, at 5, 7; Snead, *supra* note 45, at 1286.

92. Powerful new tools of statistical analysis are now being applied to fMRIs, yielding an ever-deeper understanding of the human brain. Additionally, recent techniques have combined both EEG and fMRI to produce an even more accurate imaging technology. Annabelle Belcher & Walter Sinnott-Armstrong, *Neurolaw*, 1 WIRES COGNITIVE SCI. 18, 18, 21 (2010).

93. Snead, *supra* note 45, at 1285–86.

multiple trials on subjects over a short period of time, enhancing the reliability and validity of results.[94]

e. Brain Fingerprinting (BF)

BF is a more recently developed incarnation of EEG. BF "matches information stored in the brain with information from the crime scene."[95] Electrodes placed on a subject's scalp measure a specific electrical impulse, a brain wave known as P300, that is emitted when a subject "recognizes and processes an incoming stimulus that is significant or noteworthy," but not if the stimulus is "insignificant."[96] BF purports to measure only information processing and not emotional responses, and its creator claims it cannot be manipulated or controlled by the subject.[97] Therefore, BF claims to give an accurate reading of "information present" or "information absent" in the brain.[98] With the potential to be used for brain-based lie detection, BF has already been proffered in at least two cases.[99] However, there is considerable controversy over its use for lie detection purposes.[100] In fact, there is much debate within the scholarly community over whether any brain-based lie detection should be used in the courtroom.[101]

f. Brain Electrical Oscillations Signature Test (BEOS)

Like qEEG and BF, BEOS is a recycled use of EEG. Developed by an Indian neuroscientist and built on techniques similar to BF, BEOS can purportedly distinguish people's memories of events they witnessed from deeds they committed.[102] Electrodes are attached to the subject's head and the subject is presented with stimuli in the form of sentences or pictures. Neutral stimuli are also included to normalize the software so that it can

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94. *Id.*; *cf. supra* note 75 and accompanying text (describing danger of repeated PET and SPECT scans).

95. *Interview with Dr. Lawrence Farwell: Frequently Asked Questions About Brain Fingerprinting Testing*, BRAIN FINGERPRINTING LABORATORIES, http://brainwavescience.com/FreqAskedQuestions.php (last visited Sept. 21, 2011).

96. *Brain Fingerprinting Laboratories: Scientific Procedure, Research, and Applications*, BRAIN FINGERPRINTING LABORATORIES, http://brainwavescience.com/TechnologyOverview.php (last visited Sept. 21, 2011).

97. *Id.*

98. *Id.*

99. *See* Harrington v. State, 659 N.W.2d 509, 512 (Iowa 2003); Slaughter v. State, 2005 OK CR 6, 108 P.3d 1052, 1054 (Okla. Crim. App.).

100. *Compare* Greely & Illes, *supra* note 90, at 387–88 (documenting the shortcomings of brain fingerprinting and how it should not be used for lie detection in courts), *with* Judy C. Barillare, Comment, *As Its Next Witness, the State Calls . . . the Defendant: Brain Fingerprinting As "Testimonial" Under the Fifth Amendment*, 79 TEMP. L. REV. 971, 1003–04 (2006) (arguing that BF may have some pitfalls, but it has the potential to be an effective tool in ensuring justice in certain circumstances).

101. *See generally* Jane Campbell Moriarty, *Visions of Deception: Neuroimages and the Search for Truth*, 42 AKRON L. REV. 739 (2009) (arguing that fMRI-based lie detection is currently insufficiently reliable to be used in court); *infra* note 115.

102. Anand Giridharadas, *India's Novel Use of Brain Scans in Courts Is Debated*, N.Y. TIMES, Sept. 15, 2008, at A10.

distinguish memories from normal cognitive function.[103] The test claims to detect both conceptual and experiential knowledge.[104] BEOS has already been used in India to convict at least one person of murder.[105]

2. Functional Brain Imaging in the Courtroom

Functional neuroimaging has serious implications for many legal issues. Researchers have found that several brain regions are functionally impaired in antisocial, psychopathic, and aggressive individuals.[106] Findings such as these have the potential to redefine many legal concepts such as mens rea,[107] addiction,[108] criminal responsibility,[109] and competency to stand trial[110] or be sentenced.[111] Functional neuroimaging also has implications for privacy,[112] bias detection,[113] prediction of future criminal behavior,[114] and lie detection.[115] Functional neuroimaging certainly has many potential

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103. *Id.*

104. Johnson, *supra* note 55, at 34–35.

105. *Id.*

106. *See* Erica Beecher-Monas & Edgar Garcia-Rill, *The Law and the Brain: Judging Scientific Evidence of Intent*, 1 J. APP. PRAC. & PROCESS 243, 268 (1999) (citing studies); Yang et al., *supra* note 48, at 74. *See generally* Adrian Raine & Yalin Yang, *The Neuroanatomical Bases of Psychopathy: A Review of Brain Imaging Findings*, *in* HANDBOOK OF PSYCHOPATHY 278, 278 (Christopher J. Patrick ed., 2006) (finding functional brain abnormalities in psychopathic individuals); Sapolsky, *supra* note 40, at 236–38; John Matthew Fabian, *Neuropsychological and Neurological Correlates in Violent and Homicidal Offenders: A Legal and Neuroscience Perspective*, 15 AGGRESSION & VIOLENT BEHAV. 209 (2010); Young et al., *supra* note 40.

107. *See, e.g.*, United States v. Williams, No. CR 06-00079, 2009 WL 424583, at *5–6, 12 (D. Haw. Feb. 20, 2009) (suggesting that fMRI and EEG could provide, and possibly with sufficient reliability, evidence of a defendant's inability to form requisite intent). *See generally* Brown & Murphy, *supra* note 54.

108. *See* Floyd E. Bloom, *Does Neuroscience Give Us New Insights into Drug Addiction? in* A JUDGE'S GUIDE, *supra* note 52, at 42, 42–45 (suggesting that functional neuroimaging will help scientists understand addiction, which will likely effect changes in both law and policy regarding addiction).

109. Adrian Raine, *From Genes to Brain to Antisocial Behavior*, 17 CURRENT DIRECTIONS PSYCHOL. SCI. 323, 327 (2008) (suggesting that criminals with brain dysfunction should not be held criminally responsible for their actions).

110. United States v. Kasim, No. 2:07 CR 56, 2008 WL 4822291, at *19–20 (N.D. Ind. Nov. 3, 2008) (using SPECT scan to determine competency to stand trial), *supplemented by* 2010 WL 339084 (N.D. Ind. Jan. 21, 2010).

111. United States v. Gigante, 996 F. Supp. 194, 229, 237–38 (E.D.N.Y. 1998) (admitting PET scan to show defendant's competency to be sentenced, but ultimately finding it unpersuasive).

112. *See, e.g.*, Roskies, *supra* note 57, at 67 ("Privacy law is apt to become important with respect to these technologies."); Stacey A. Tovino, *The Confidentiality and Privacy Implications of Functional Magnetic Resonance Imaging*, 33 J.L. MED. & ETHICS 844 (2005).

113. *See, e.g.*, Eagleman, *supra* note 6, at 39; Henry T. Greely, *Prediction, Litigation, Privacy, and Property: Some Possible Legal and Social Implications of Advances in Neuroscience*, *in* NEUROSCIENCE AND THE LAW: BRAIN, MIND AND THE SCALES OF JUSTICE 114, 137–38 (Brent Garland ed., 2004) [hereinafter NEUROSCIENCE AND THE LAW].

114. Henry T. Greely, *The Social Effects of Advances in Neuroscience: Legal Problems, Legal Perspectives*, *in* NEUROETHICS, *supra* note 55, at 245, 246–50.

115. *See generally* EMILIO BIZZI ET AL., USING IMAGING TO IDENTIFY DECEIT: SCIENTIFIC AND ETHICAL QUESTIONS (2009) (discussing implications of neurological-based lie

uses in the legal realm. Yet there remains an ever-important hurdle for it to clear. Before any evidence, whether neuroscientific or otherwise, can be used in the courtroom, it must pass the standards for evidence admissibility.

C. Admissibility Standards: The Daubert *Trilogy and the Federal Rules of Evidence*

Although there are numerous legal applications of functional neuroimaging, if it is to be presented at trial, it must first clear an admissibility hurdle. This section discusses the current federal standard for admitting scientific evidence.

1. The "*Daubert* Trilogy"

The current standard for scientific evidence and expert testimony admissibility follows what is collectively known as the "*Daubert* trilogy."[116] In *Daubert v. Merrell Dow Pharmaceuticals, Inc.*,[117] the U.S. Supreme Court declared that Rule 702 of the Federal Rules of Evidence (Rules) superseded the "general acceptance" test from *Frye v. United States*.[118] The *Frye* "general acceptance" test had held that expert testimony was admissible if it was generally accepted as reliable in the relevant scientific community.[119] In *Daubert*, however, the Court ruled that the appropriate standard was Rule 702, which said that scientific testimony must be "not only relevant, but reliable," thus removing the absolute requirement that the scientific evidence be "generally accepted" in the relevant scientific community.[120] *Daubert* requires judges to determine whether the "reasoning or methodology" underlying the evidence is "scientifically valid" such that it can be properly applied to the particular case.[121] Because the inquiry is "a flexible one,"[122] judges have discretion

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detection); Sarah E. Stoller & Paul Root Wolpe, *Emerging Neurotechnologies for Lie Detection and the Fifth Amendment*, 33 AM. J.L. & MED. 359 (2007) (discussing constitutional concerns of brain-based lie detection); Leo Kittay, Note, *Admissibility of fMRI Lie Detection: The Cultural Bias Against "Mind Reading" Devices*, 72 BROOK. L. REV. 1351 (2007) (arguing that neurological lie detection should be admitted as evidence).

116. *See, e.g.*, Truck Ins. Exch. v. MagneTek, Inc., 360 F.3d 1206, 1209 (10th Cir. 2004) (identifying the "*Daubert* trilogy").

117. 509 U.S. 579 (1993).

118. 293 F. 1013 (D.C. Cir. 1927).

119. *Daubert*, 509 U.S. at 584–85, 587. Although Rule 702 became the federal standard, the states have disagreed regarding the proper standard to apply. Most adopted *Daubert* or a similar standard, but a minority of states and the District of Columbia continue to use the *Frye* test. A few states have combined the *Daubert* and *Frye* tests, and still others have created their own tests entirely. *See* Brown & Murphy, *supra* note 54, at 1176; Maxine D. Goodman, *A Hedgehog on the Witness Stand—What's the Big Idea?: The Challenges of Using* Daubert *to Assess Social Science and Nonscientific Testimony*, 59 AM. U. L. REV. 635, 644 n.36 (citing sources that illustrate jurisdictional differences in standards for expert testimony, and listing states that still use the *Frye* test); Patel et al., *supra* note 33, at 560–61.

120. *Daubert*, 509 U.S. at 589.

121. *Id.* at 593; *see also* Margaret A. Berger, *The Supreme Court's Trilogy on the Admissibility of Expert Testimony*, *in* REFERENCE MANUAL ON SCIENTIFIC EVIDENCE 9, 11–12 (Fed. Judicial Ctr., 2d ed. 2000).

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

when acting as "gatekeepers" to ensure that the scientific testimony is both relevant and reliable.[123]

As the Court noted, "[i]n a case involving scientific evidence, *evidentiary reliability* will be based upon *scientific validity*."[124] Thus, for purposes of satisfying *Daubert*, scientific reliability depends on whether an investigatory method passes muster as a valid scientific process. The Court determined that when considering the admissibility of scientific evidence, a judge must focus solely on the principles and methodologies utilized in the scientific process and not on the conclusions drawn from those methodologies.[125]

To help judges determine if the proffered evidence is scientifically valid (i.e., based on the scientific method), the Court suggested a number of guidelines for judges to consider. First, the underlying method should be empirical, meaning that the technique should be testable and open to scientific criticism.[126] Second, judges should consider whether the technique is subject to peer review and publication.[127] Third, the technique should have a known or potential rate of error.[128] Fourth, judges should consider whether the technique is standardized or whether regulations control its use.[129] Finally, with a nod to the *Frye* test, the Court included general acceptance of the methodology within the scientific community as a factor for courts to consider, although this factor is no longer dispositive.[130]

The Court noted that many factors will bear on an admissibility inquiry and it did "not presume to set out a definitive checklist or test."[131] Thus, the Court was careful to grant judges the flexibility to remain relatively subjective in their inquiry while providing an identifiable framework in which to operate.

In its conclusion, the Court addressed the dissenters' concerns about the decision's lasting impact.[132] The dissenting Justices worried that abandoning *Frye* would "result in a 'free-for-all' in which befuddled juries would be confounded by absurd and irrational pseudoscientific

123. *Id.* at 589 & n.7.

124. *Id.* at 590 n.9.

125. *Id.* at 595.

126. *Id.* at 593. This is an important factor to determine whether evidence is scientifically valid because testing and criticism is part of scientific inquiry, which leads to further scientific progress. *See* David Goodstein, *How Science Works*, *in* REFERENCE MANUAL ON SCIENTIFIC EVIDENCE, *supra* note 121, at 67, 70 ("[S]cience makes progress uniquely by proving that good ideas are wrong so that they can be replaced by even better ideas.").

127. *Daubert*, 509 U.S. at 593. However, the Court was keen to emphasize that "[p]ublication . . . is not a *sine qua non* of admissibility; it does not necessarily correlate with reliability . . . and in some instances well-grounded but innovative theories will not have been published." *Id.*

128. *Id.* at 594.

129. *Id.*

130. *Id.*; Berger, *supra* note 121, at 12–13 ("[G]eneral acceptance of the methodology within the scientific community is no longer dispositive . . . .").

131. *Daubert*, 509 U.S. at 593–94. Additional guidelines are mentioned in the advisory committee's notes to Rule 702. *See* FED. R. EVID. 702 advisory committee's notes.

132. *Daubert*, 509 U.S. at 595.

assertions."[133] The Court dismissed these concerns by reaffirming its faith in the adversary system of the courtroom, labeling naysayers as "overly pessimistic about the capabilities of the jury and of the adversary system generally."[134] Clarity would be achieved through "[v]igorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof."[135]

In *General Electric Co. v. Joiner*,[136] the Supreme Court announced that the correct standard of review for an evidentiary ruling is abuse of discretion.[137] In a concurring opinion, Justice Breyer urged trial judges to take appropriate measures to manage their gatekeeping duties.[138] Justice Breyer advocated appointing reputable experts, or "special masters," to help determine the scientific validity, and thus evidentiary reliability, of scientific evidence.[139]

The last of the "*Daubert* trilogy," *Kumho Tire Co. v. Carmichael*[140] extended *Daubert* to encompass all expert testimony.[141] *Kumho Tire* involved the analysis and deposition testimony of a tire-failure expert who drew his conclusions after visually inspecting the tires.[142] The Court found that a judge's gatekeeping duties extend to *all* expert testimony involving "scientific," "technical," or "other specialized" knowledge.[143] Thus, today, whether expert-based testimony is scientific in nature or based on "skill- or experience-based observation," the same evidentiary standard applies.[144]

The Court also reiterated that *Daubert*'s guiding factors were "meant to be helpful, not definitive," and that trial courts have discretion in deciding whether or not evidence is admissible, because that determination is largely fact-dependent.[145] Hence, the notion that the *Daubert* factors must be applied to every case was categorically rejected.[146]

The *Daubert* admissibility standard can be distilled to a few key points. Trial judges must assess the relevance of the proffered evidence.[147] They

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133. *Id.*

134. *Id.* at 596.

135. *Id.*; *see also* Pettit, Jr., *supra* note 74, at 325. The Court also mentioned that judges can issue directed verdicts or grant summary judgment as "conventional devices" of the courtroom to protect against the intrusion and preponderance of "pseudoscientific" science. *Daubert*, 509 U.S. at 595.

136. 522 U.S. 136 (1997).

137. *Id.* at 139.

138. *Id.* at 150 (Breyer, J., concurring).

139. *Id.* at 149–50; *see* FED. R. EVID. 706. However, judges have been reluctant to appoint such experts. *See, e.g.*, Ass'n of Mex.-Am. Educators v. California, 231 F.3d 572, 590, 612–14 (9th Cir. 2000) (Tashima, J., dissenting) (noting that court-appointed experts are appropriate in "rare" cases, and there is fear they could take away from the role of the judge or jury).

140. 526 U.S. 137 (1999).

141. *Id.* at 141.

142. *Id.* at 146.

143. *Id.* at 141.

144. *See* Berger, *supra* note 121, at 18.

145. *Kumho Tire*, 526 U.S. at 150–51; *see also* Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 593–94 (1993).

146. *See* Berger, *supra* note 121 at 19.

147. *Daubert*, 509 U.S. at 593–94.

must also determine the scientific validity underlying the evidence's methodology,[148] and they may appoint an expert to assist the court if necessary.[149] This applies to all forms of expert testimony, holding each expert to the same standards of "intellectual rigor."[150] Once admitted, evidentiary rulings are subject to the deferential "abuse of discretion" standard of review, effectively granting trial judges the final say in evidentiary matters.[151] The story of scientific evidence admissibility, however, does not end there.

2. Post-*Daubert* Trilogy: The Federal Rules of Evidence

Like most scientific evidence, functional neuroimaging evidence requires an expert to interpret the scans for the jury or testify about the results of the scan.[152] The Rules regulating expert testimony are therefore pertinent to this discussion.

In 2000, Rule 702, which currently requires that any expert testimony "assist the trier of fact to understand the evidence or to determine a fact in issue,"[153] was amended to reflect the *Daubert* trilogy.[154] The amendment called for judges to engage in three general categories of inquiry when acting as gatekeepers.[155] The expert testimony must be "based upon sufficient facts or data," it must be the "product of reliable principles and methods," and the testimony must be "reliably [applied] to the facts of the case."[156] However, it does *not* require that the evidence be "generally accepted" within the relevant scientific community. Neither the Federal Rules of Evidence nor the *Daubert* trilogy categorically restrict judges from admitting evidence that is not uniformly accepted within the scientific community.

Rule 403 also informs a discussion of brain scan admissibility. Even if evidence is relevant, it may still be excluded "if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or [if it is] misleading [to] the jury."[157] Juries can be swayed by the "impressive title[s]" of scientists in the courtroom, attributing greater weight to their testimony than is deserved and creating problems of sophistry.[158] Thus, while evidence may pass admissibility standards under

148. *Id.* at 592–93, 595.

149. Gen. Electric Co. v. Joiner, 522 U.S. 136, 150 (1997) (Breyer, J., concurring). *See generally* Sheila Jasanoff, *Hidden Experts: Judging Science After* Daubert, *in* TRYING TIMES: SCIENCE AND RESPONSIBILITIES AFTER *DAUBERT* 30, 30 (Vivian Weil ed., 2001).

150. *Kumho Tire*, 526 U.S. at 152.

151. *Id.* at 142 (citing *Joiner*, 522 U.S. at 143).

152. *See* Pettit, Jr., *supra* note 74, at 323 ("[B]rain-imaging evidence seems necessarily to entail presentation by expert witnesses . . . .").

153. FED. R. EVID. 702.

154. FED. R. EVID. 702 advisory committee's notes.

155. CHRISTOPHER B. MUELLER ET AL., EVIDENCE: PRACTICE UNDER THE RULES 719 (3d ed. 2009).

156. FED. R. EVID. 702.

157. FED. R. EVID. 403.

158. KENNETH R. FOSTER & PETER W. HUBER, JUDGING SCIENCE: SCIENTIFIC KNOWLEDGE AND THE FEDERAL COURTS 209, 250 (1997).

Daubert and Rule 702, a judge may still exclude evidence under Rule 403.[159] Rule 403 is important to the present discussion because some critics worry that testimony about brain scans will provide an air of infallibility and strongly prejudice or mislead a jury, what some refer to as the "Christmas tree effect."[160]

Rule 704 also informs a discussion of functional neuroimaging evidence.[161] It defines the scope of admissible expert testimony when the expert testimony concerns a defendant's mental state. According to the rule, the expert may not testify as to whether a defendant definitively did or did not have a specific mental state necessary for a specific crime because "[s]uch ultimate issues are matters for the trier of fact alone."[162] While Rule 704 has largely been subsumed by Rule 702's requirement that the testimony "assist the finder of fact"[163] and by Rule 403's protection against misleading or confusing the jury,[164] it still stands to prevent experts from testifying if they will "merely tell the jury what result to reach."[165]

While theoretically simple, the practical impact of *Daubert* remains unclear, and has created both confusion and controversy.[166] One study of 372 federal and 321 state criminal appellate cases from 1988 to 1999 found no change in admissibility rates under *Daubert* as compared with the older *Frye* standard.[167] Scholars and commentators argue that while judges often cite *Daubert* in their analyses, the standard is not applied in any meaningful way.[168] A recent report found that "[f]ederal appellate courts have not with any consistency or clarity imposed standards ensuring the application of scientifically valid reasoning and reliable methodology in criminal cases involving *Daubert* questions."[169]

3. The Role of the Jury After *Daubert*

Daubert requires judges to act as gatekeepers of scientific evidence, but it does not substitute them for the jury or for the adversarial legal system in

159. *See, e.g.*, United States v. Pohlot, 827 F.2d 889 (3d Cir. 1987) (finding evidence of brain abnormality to be reliable and relevant but excluding it because of its potential to mislead the jury); United States v. Mezvinsky, 206 F. Supp. 2d 661, 674–77 (E.D. Pa. 2002) (denying proffered PET scans due to their potential to mislead the jury).

160. *See infra* Part II.A.4 (presenting arguments that functional neuroimaging should be excluded under Rule 403). *But see infra* Part II.B.5 (presenting counterarguments).

161. FED. R. EVID. 704.

162. *Id.*

163. FED. R. EVID. 702.

164. FED. R. EVID. 704 advisory committee's notes.

165. *Id.*

166. COMM. ON IDENTIFYING THE NEEDS OF THE FORENSIC SCIS. CMTY., NAT'L RESEARCH COUNCIL, STRENGTHENING FORENSIC SCIENCES IN THE UNITED STATES: A PATH FORWARD 11 (2009) [hereinafter NRC REPORT] (describing inconsistency among federal courts in applying, misapplying, or not applying *Daubert* in criminal cases).

167. *See* Edward K. Cheng & Albert H. Yoon, *Does* Frye *or* Daubert *Matter? A Study of Scientific Admissibility Standards*, 91 VA. L. REV. 471, 478–79 (2005).

168. *See, e.g.*, NRC REPORT, *supra* note 166, at 11; Cheng & Yoon, *supra* note 167, at 479 n.25.

169. NRC REPORT, *supra* note 166, at 11.

general.[170] For example, the judge cannot decide whether an expert's testimony is factually correct, nor can the judge pass judgment on any conclusions drawn by an expert from a particular methodology.[171] Rather, it is for the jury to decide whether the expert is correct in his or her assessment.[172] The judge must focus solely on how the expert arrived at his or her opinion.[173]

Although courts have inconsistently applied *Daubert*,[174] they have consistently reaffirmed the jury's role in assessing the reliability of scientific evidence, finding that sufficiently probative evidence will not be excluded despite its potential to mislead or confuse the jury.[175] After all, "Rule 403 is a rule that favors admissibility."[176] In *United States v. Starzecpyzel*,[177] the court found that evidence was prejudicial because the jury could attribute it "far greater precision and reliability" than is otherwise appropriate.[178] However, the court did not exclude it under Rule 403, stating that, "[w]hile the Court does not take the problem of prejudice lightly, it is also important not to overreact to it."[179] The court took protective measures to mitigate any potential prejudicial effect[180] and admitted the evidence, stating that "'[t]he jury is intelligent enough, aided by counsel, to ignore what is unhelpful in its deliberations.'"[181] In that

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170. *See* MUELLER, *supra* note 155, at 716. A defendant's right to a trial by jury is an underlying principle of our criminal justice system. *See* U.S. CONST. amend. VI.

171. *See* Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 595 (1993) ("The focus, of course, must be solely on principles and methodology, not on the conclusions that they generate."); Smith v. Ford Motor Co., 215 F.3d 713, 719 (7th Cir. 2000) ("It is not the trial court's role to decide whether an expert's opinion is correct. The trial court is limited to determining whether expert testimony is pertinent to an issue in the case and whether the methodology underlying that testimony is sound.").

172. *See Ford Motor Co.*, 215 F.3d at 719.

173. *See Daubert*, 509 U.S. at 594–95. Failure to focus solely on how the expert arrived at his or her conclusions can constitute reversible error. *See, e.g.*, Deputy v. Lehman Bros., 345 F.3d 494, 508 (7th Cir. 2003) (finding that the district court incorrectly excluded expert testimony for reasons relevant to valuing the testimony rather than questioning its method of analysis).

174. *See supra* notes 166–69 and accompanying text (discussing the confusion and disparity in applying *Daubert*).

175. *See, e.g.*, United States v. Ochoa-Ramirez, 386 F. App'x 641, 642 (9th Cir. 2010) (admitting prejudicial evidence because it had probative value and its prejudicial effect was mitigated by limiting jury instructions); United States v. McRae, 593 F.2d 700, 707 (5th Cir. 1979) ("Relevant evidence is inherently prejudicial; but it is only *unfair* prejudice, *substantially* outweighing probative value, which permits exclusion of relevant matter under Rule 403."); United States v. Starzecpyzel, 880 F. Supp. 1027, 1029 (S.D.N.Y. 1995) (describing the same).

176. Daniel J. Capra, *Exclusion and Admissibility Under Rule 403*, 212 N.Y. L.J. 3, 3 (1994).

177. 880 F. Supp. 1027 (S.D.N.Y. 1995).

178. *Id.* at 1029.

179. *Id.* at 1049.

180. The court mitigated the prejudicial effect of the evidence by giving the jury specific instructions not to grant the testimony more weight than was appropriate, and the court noted that it could also restrict the degree of certainty with which the expert testifies. *Id.* at 1049–50.

181. *Id.* at 1049 (quoting 3 JACK B. WEINSTEIN & MARGARET A. BERGER, WEINSTEIN'S EVIDENCE § 702[03], at 702–03 (1989)); *see also* United States v. Mitchell, 365 F.3d 215,

case, the probative value outweighed the potential prejudicial effect. This reaffirmed the Supreme Court's vote of confidence in the aptitude and utility of the jury and in the adversarial system,[182] which the Court has repeatedly recognized as "'the greatest legal engine ever invented for the discovery of the truth.'"[183] Scholars point out that while jurors may not enter the courtroom with extensive scientific or technical knowledge, if any at all, their collective experiences still warrant their participation in "legal decision making," even when the decisions are based on scientific evidence.[184]

D. Forensic Science Evidence Under Daubert

Following *Daubert*, scholars were both skeptical and critical of the decision's practical impact.[185] One major criticism was that *Daubert* presumed that science operates on "objective standards that can be clearly understood and applied by judges" when in fact those standards vary widely.[186] Judges often evaluate scientific evidence based on their own assumptions about the nature of the evidence, analyzing the evidence under personalized methods and standards.[187] This creates confusion and discrepancy as "litigants with similar complaints are subjected by gatekeeping judges to substantially different evidentiary standards and validation processes."[188] The forensic sciences provide a salient example

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245 (3d Cir. 2004) ("'[A] party confronted with an adverse expert witness who has sufficient, though perhaps not overwhelming, facts and assumptions as the basis for his opinion can highlight those weaknesses through effective cross-examination.'" (quoting Stecyk v. Bell Helicopter Textron, Inc., 295 F.3d 408, 414 (3d Cir. 2002))).

182. *See supra* notes 134–35 and accompanying text.

183. White v. Illinois, 502 U.S. 346, 356 (1992) (quoting California v. Green, 399 U.S. 149, 158 (1970)); *see also* Melendez-Diaz v. Massachusetts, 129 S. Ct. 2527, 2536 (2009) (recognizing that cross-examination is a constitutionally guaranteed method of testing the reliability of forensic evidence).

184. Patricia M. Ayd & Merle M. Troeger, *Are Jurors Smart Enough to Understand Scientific Evidence?*, *in* EXPERT WITNESSING: EXPLAINING AND UNDERSTANDING SCIENCE 38 (Carl Meyer ed., 1999); *see also* Richard D. Friedman, *Squeezing* Daubert *Out of the Picture*, 33 SETON HALL L. REV. 1047, 1061–64 (2003) (arguing that jurors would not be unfairly prejudiced or misled by such evidence and should be presented with the evidence because they still effectively serve as finders of fact).

185. *See, e.g.*, CHRISTOPHER SLOBOGIN, PROVING THE UNPROVABLE: THE ROLE OF LAW, SCIENCE, AND SPECULATION IN ADJUDICATING CULPABILITY AND DANGEROUSNESS 139–43 (2007) (describing *Daubert*'s potential damage to the criminal justice system); Friedman, *supra* note 184, at 1047 (describing how the admissibility model created by the *Daubert* trilogy "is not a useful one"); Jasanoff, *supra* note 149, at 30–31; *see also* Andrew Jurs, *Judicial Analysis of Complex & Cutting-Edge Science in the* Daubert *Era: Epidemiologic Risk Assessment as a Test Case for Reform Strategies*, 42 CONN. L. REV. 49, 52, 69–84 (2009) (identifying multiple weaknesses displayed by courts when applying *Daubert*).

186. Jasanoff, *supra* note 149, at 44; *see also id.* at 45 ("[D]espite *Daubert*'s suggestions to the contrary, there are no universally applicable rules for evaluating scientific validity in all litigation contexts."); *see also* Friedman, *supra* note 184, at 1047–48 (remarking how the *Daubert* admissibility standard is both insufficient and inappropriately applied because trial courts are ill suited to sort the good from the bad, and it misdirects the appropriate focus for a useful evidentiary standard).

187. Jasanoff, *supra* note 149, at 44.

188. *Id.*

of how judges apply different evidentiary standards and validation processes.

One of the goals of *Daubert* was to weed out "junk science" from the courtroom.[189] As gatekeepers, judges are supposed to ban empirically unreliable evidence under the strictures of *Daubert* and Rule 702.[190] But scholars have pointed out that judges have failed to do so, particularly in the criminal context.[191] Studies have shown that judges are especially lax in applying *Daubert* to forensic evidence proffered by prosecutors in criminal trials.[192] A recent report notes that much of forensic evidence severely lacks scientific validity and reliability, yet the courts have been "utterly ineffective in addressing this problem."[193] Although some district courts have begun to question the scientific underpinnings of forensic science evidence under *Daubert*, the trend has been slow to reach the appellate level.[194] To understand the relevance of forensic evidence to functional neuroimaging evidence, forensic evidence must first be understood.

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189. Gen. Electric Co. v. Joiner, 522 U.S. 136, 153 & n.6 (1997); *see also* Amorgianos v. Nat'l R.R. Passenger Corp., 303 F.3d 256, 267 (2d Cir. 2002) ("The flexible *Daubert* inquiry . . . [helps] ensure that the courtroom door remains closed to junk science while admitting reliable expert testimony that will assist the trier of fact.").

190. *See supra* notes 126–31 and accompanying text (summarizing the judge's gatekeeping role).

191. *See, e.g.*, Paul C. Giannelli, *The Supreme Court's "Criminal"* Daubert *Cases*, 33 SETON HALL L. REV. 1071, 1072, 1073 n.12 (noting the difference in admissibility standards between civil and criminal cases and how experts offered by the prosecution have been "largely insulated from any change in pre-*Daubert* standards"); *see also* Jane Campbell Moriarty, Daubert*, Innocence, and the Future of Forensic Science*, 43 TULSA L. REV. 229, 229–30 (2007) (listing scholars who discuss how judges have been lax in their gatekeeping role).

192. *See* DAVID L. FAIGMAN ET AL., MODERN SCIENTIFIC EVIDENCE: THE LAW AND SCIENCE OF EXPERT TESTIMONY § 1:35 (2009–2010 ed.); NRC REPORT, *supra* note 166, at 11 ("[T]he vast majority of the *reported* opinions in criminal cases indicate that trial judges rarely exclude or restrict expert testimony offered by prosecutors; most *reported* opinions also indicate that appellate courts routinely deny appeals contesting trial court decisions admitting forensic evidence against criminal defendants."); *see also* Giannelli, *supra* note 191, at 1111.

193. NRC REPORT, *supra* note 166, at 53. Despite the fact that these problems were first acknowledged almost twenty years ago, little has been done to change the frequency of their courtroom use. *See* Michael J. Saks & Jonathan J. Koehler, *What DNA "Fingerprinting" Can Teach the Law About the Rest of Forensic Science*, 13 CARDOZO L. REV. 361, 372 (1991) (noting that forensic scientists need to "subject their claims to methodologically rigorous empirical tests" that should then be "published and debated," but until such steps are taken, their claims should be "regarded with far more caution than they traditionally have been"); *cf. infra* notes 224–25 and accompanying text (citing cases where forensic science continues to be used in the courtroom without much attention paid to scientific reliability).

194. *See, e.g.*, Ege v. Yukins, 380 F. Supp. 2d 852, 871 (E.D. Mich. 2005) (finding bitemark evidence "unreliable and not worthy of consideration by a jury"), *aff'd in part, rev'd in part on other grounds*, 485 F.3d 364 (6th Cir. 2007); United States v. Hidalgo, 229 F. Supp. 2d 961, 967 (D. Ariz. 2002) (finding that handwriting analysis fails to pass *Daubert)*; United States v. Llera Plaza, 188 F. Supp. 2d 549, 558, 576 (E.D. Pa. 2002) (excluding and then admitting fingerprint evidence, finding it sufficiently reliable under *Daubert* only when subject to "careful trial court oversight"); United States v. Saelee, 162 F. Supp. 2d 1097, 1103, 1105–06 (D. Alaska 2001) (finding that handwriting analysis fails to pass *Daubert*); *see also* Deputy v. Lehman Bros., 345 F.3d 494, 509 (7th Cir. 2003) (noting disparity in admissibility of handwriting analysis between circuit courts and district courts).

Because functional neuroimaging has great potential for the criminal justice system, and particularly for defendants,[195] the next section of this Note discusses how *Daubert* affected one of the most important aspects of criminal evidence: forensic science evidence, and in particular, forensic individualization evidence.

1. Forensic Individualization as Scientific Evidence

Forensic science evidence has three main purposes: identification, individualization, and reconstruction.[196] The purpose of forensic identification is to identify a substance and quantify or measure it.[197] For example, a police officer might send a bag of white powder confiscated during an arrest to a forensics lab to determine whether it contains cocaine and if so, how much.[198] Classic forensic sciences such as this are considered highly reliable[199] and are rarely challenged under *Daubert* or Rule 702 unless there is evidence of negligence or fraud.[200]

Forensic individualization has an entirely different goal. Instead of identifying or quantifying a particular substance based on inherent or objective characteristics, forensic individualization relies on the "expert interpretation of observed patterns"[201] in order to "associate an item of evidence found at a crime scene with its unique source, to the exclusion of all others."[202] Forensic individualization experts rely on principles of basic probability, which state that the likelihood that a unique trait is shared by two different objects is extremely small.[203] Thus, by analyzing the "uniqueness" of an object and comparing it to known samples of the same or similar objects, forensic individualization experts claim to identify the source of the object.[204] This type of analysis makes exclusion easier than association, meaning that it is much easier for an expert to rule out a possible source for the specific object than to definitively "match" it to a source.[205] In fact, "[t]he claim of unique individualization has never been demonstrated for any forensic individualization science through empirical

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195. *See supra* notes 106–15 and accompanying text.

196. Moriarty & Saks, *supra* note 17, at 17. This Note focuses on forensic individualization and compares it to functional brain scans.

197. *See* FAIGMAN ET AL., *supra* note 192, § 30:19; Moriarty & Saks, *supra* note 17, at 17.

198. *See, e.g.*, Melendez-Diaz v. Massachusetts, 129 S. Ct. 2527, 2530–31 (2009) (describing forensic identification of cocaine); United States v. Rivera-Rodriguez, 617 F.3d 581, 599, 607 (1st Cir. 2010) (reviewing forensic analyst's description of crack cocaine), *cert. denied*, 131 S. Ct. 968 (2011).

199. NRC REPORT, *supra* note 166, at 135; Moriarty & Saks, *supra* note 17, at 17.

200. Moriarty & Saks, *supra* note 17, at 17. As a recent student note points out, "[t]he American criminal justice system is no stranger to forensic falsification." Kristen Bolden, Note, *DNA Fabrication, A Wake Up Call: The Need to Reevaluate the Admissibility and Reliability of DNA Evidence*, 27 GA. ST. U. L. REV. 409, 417 (2011).

201. NRC REPORT, *supra* note 166, at 7.

202. Moriarty & Saks, *supra* note 17, at 17; *see also* FAIGMAN ET AL., *supra* note 192, § 30:19.

203. Moriarty & Saks, *supra* note 17, at 18.

204. *Id.* Forensic individualization experts use similar methods to identify a specific subpopulation of people who share the unique trait. *Id.*

205. *Id.* at 18–19.

testing."[206] Yet, as scholars point out, this has not prevented some forensic experts from claiming that they can definitively match an item to its source.[207]

For example, in *United States v. Green*,[208] prosecutors sought to call a ballistics expert to testify that fourteen shell casings found on a street were all fired from the same weapon.[209] The expert claimed to be able to match the shell casings to a specific firearm "to the exclusion of every other firearm in the world."[210] Recognizing the "sloppy practices"[211] and "serious deficiencies"[212] of the forensic technique, the court nevertheless allowed the expert to testify but prohibited him from testifying that he could identify the gun to the exclusion of all other firearms.[213]

Often called "non-science forensic sciences," forensic individualization sciences include what could be considered a typical lineup of forensic evidence: analyses of fingerprints, shoe prints, bite marks, tool marks, firearms (ballistics), handwriting, hair samples, and DNA, among others.[214] Though they are not based on typical scientific methods of analysis, with the exception of forensic DNA analysis,[215] forensic individualization

206. Michael J. Saks, *Explaining the Tension Between the Supreme Court's Embrace of Validity as the Touchstone of Admissibility of Expert Testimony and Lower Court's (Seeming) Rejection of Same*, 5 EPISTEME 329, 331 (2008).

207. *See, e.g.*, NRC REPORT, *supra* note 166, at 141–43 (stating that fingerprint experts often testify in objective terms such as "absolute certainty" or "zero error rates," assertions that are "not scientifically plausible" and "[c]learly . . . unrealistic"); Moriarty & Saks, *supra* note 17, at 20 (describing same); *see also* Duncan v. Ornoski, 528 F.3d 1222, 1237 (9th Cir. 2008) (recounting fingerprint expert's testimony and court's reliance thereon that fingerprints "can be ascribed to a specific individual with certainty"), *aff'd*, 286 F. App'x 361 (9th Cir. 2008); United States v. Hall, 905 F.2d 959, 963 (6th Cir. 1990) (Kennedy, J., concurring) (quoting handwriting expert's testimony that was "'virtually certain that [the defendant] wrote it'"); United States v. Hugh, No. 03-829, 2009 WL 212420, at *2 (E.D. Pa. Jan. 28, 2009) (mentioning a fingerprint expert's claim of an "exact match"); United States v. Green, 405 F. Supp. 2d 104, 107 (D. Mass. 2005) (describing officer's testimony that he could match shell casings to the weapon from which it was fired "to the exclusion of every other firearm in the world"); United States v. Havvard, 117 F. Supp. 2d 848, 854 (S.D. Ind. 2000) ("The government claims the error rate for the [fingerprint] method is zero."), *aff'd*, 260 F.3d 597 (7th Cir. 2001). However, some forensic experts do testify to a "reasonable degree" of scientific or technical certainty. *See, e.g.*, Norwood v. Artis, 487 F. Supp. 2d 321, 326 (W.D.N.Y. 2007).

208. 405 F. Supp. 2d 104, 107 (D. Mass. 2005).

209. *Id.*

210. *Id.*

211. *Id.* at 109.

212. *Id.* at 108.

213. *Id.* at 124. While the ballistics expert was allowed to testify, Judge Nancy Gertner's ruling is significant because it is one of the few instances where a court recognized the failings associated with forensic science and took corrective measures. *See infra* note 274 (citing other cases that took similar measures).

214. Moriarty & Saks, *supra* note 17, at 18; Saks, *supra* note 206, at 329–30.

215. Saks, *supra* note 206, at 330. Even DNA analysis, the "gold standard" of modern forensic evidence, is not without its own analytical deficiencies. A recent study has shown that even DNA samples can be fabricated and more rigorous verification methods are necessary. *See* Dan Frumkin et al., *Authentication of Forensic DNA Samples*, 4 FORENSIC SCI. INT'L: GENETICS 95 (2010); *see also* NRC REPORT, *supra* note 166, at 130–33. *See generally* Natasha Gilbert, *DNA's Identity Crisis*, 464 NATURE 347 (2010) (questioning the

sciences still rely on expert testimony, and are therefore subject to *Daubert* and Rule 702.[216]

It is widely recognized that forensic individualization has little or no scientific, empirical, or testable foundation,[217] and there have been few if any attempts to improve them with serious research.[218] Although many forensic individualization techniques have been around for a long time,[219] they must still meet the *Daubert* standards; *Daubert* carries no "grandfather" clause that would allow the evidence to bypass the admissibility standards.[220] Moreover, the evaluation of the forensic individualization sciences is especially important in criminal *Daubert*

reliability of DNA evidence from ever-smaller human traces); Bolden, *supra* note 200 (describing deficiencies in DNA analysis and the need to reevaluate its use in court).

216. *See* FAIGMAN ET AL., *supra* note 192, § 30:2; Moriarty & Saks, *supra* note 17, at 17; *supra* notes 143–44 and accompanying text. Forensic individualization sciences would also be subject to Rules 403, 704, and others.

217. *See, e.g.*, NRC REPORT, *supra* note 166, at 14–18; Craig M. Cooley & Gabriel S. Oberfield, *Increasing Forensic Evidence's Reliability and Minimizing Wrongful Convictions: Applying* Daubert *Isn't the Only Problem*, 43 TULSA L. REV. 285, 292–94 (2007); Michael J. Saks & Jonathan J. Koehler, *The Individualization Fallacy in Forensic Science Evidence*, 61 VAND. L. REV. 199, 203–07 (2008). *See generally* Mara L. Merlino et al., *Meeting the Challenges of the* Daubert *Trilogy: Refining and Redefining the Reliability of Forensic Evidence*, 43 TULSA L. REV. 417 (2007); Jennifer L. Mnookin, *Of Black Boxes, Instruments, and Experts: Testing the Validity of Forensic Science*, 5 EPISTEME 343 (2008); Moriarty & Saks, *supra* note 17; D. Michael Risinger et al., *Exorcism of Ignorance as a Proxy for Rational Knowledge: The Lessons of Handwriting Identification "Expertise,"* 137 U. PA. L. REV. 731 (1989); Michael J. Saks, *The Legal and Scientific Evaluation of Forensic Science (Especially Fingerprint Expert Testimony)*, 33 SETON HALL L. REV. 1167 (2003); Adina Schwartz, *Firearms and Toolmark Identification Cannot Be Made to a Reasonable Degree of Certainty*, CHAMPION MAG., Nov.–Dec. 2008, at 44.

218. *See, e.g.*, NRC REPORT, *supra* note 166, at 108–09 ("'[T]he undeniable reality is that the community of forensic science professionals has not done nearly as much as it reasonably could have done to establish either the validity of its approach or the accuracy of its practitioners' conclusions,' and the courts have been 'utterly ineffective' in addressing this problem." (quoting Jennifer L. Mnookin, *The Validity of Latent Fingerprint Identification: Confessions of a Fingerprinting Moderate*, 7 L. PROBABILITY & RISK 127, 139 (2008)); *see also* Saks, *supra* note 206, at 329, 330–31 ("'[In] [a]ll the areas of forensic [identification] science . . . little rigorous, systematic research has been done to validate the discipline's basic premises and techniques, and in each area there is no evident reason why such research would be infeasible.'" (quoting Paul Giannelli & Edward Imwinkelried, *Scientific Evidence: The Fallout from Supreme Court's Decision in* Kumho Tires, 14 CRIM. JUST. 12, 40 (2000))).

219. For example, fingerprint evidence was first admitted in an American appellate proceeding in 1911. *See* People v. Jennings, 96 N.E. 1077, 1082 (Ill. 1911); FAIGMAN ET AL., *supra* note 192, § 33:2 n.9. Forensic handwriting identification has been used in litigation since at least 1832, but the first empirical study to examine handwriting identification was conducted in 1939. *See* Strother v. Lucas, 31 U.S. 763, 767 (1832); Risinger et al., *supra* note 217, at 734 n.14, 740–43.

220. *See* United States v. Williams, 506 F.3d 151, 162 (2d Cir. 2007) ("[E]xpert testimony long assumed reliable before Rule 702 must nonetheless be subject to the careful examination that *Daubert* and *Kumho Tire* require."); *see also* Richard Bjur & James T. Richardson, *Expert Testimony Involving Chemists and Chemistry*, *in* EXPERT WITNESSING: EXPLAINING AND UNDERSTANDING SCIENCE, *supra* note 184, at 67, 75; Beecher-Monas & Garcia-Rill, *supra* note 106, at 275 ("Lower courts cannot blindly accept pre-*Daubert* approved notions of expertise."); Gianelli, *supra* note 191, at 1096–99.

jurisprudence.[221] The *Daubert* standard may have been framed in a civil case initially, yet "federal courts should apply [it] with equal force to their criminal docket."[222]

Scholars widely agree that rigorous application of the *Daubert* standard is severely lacking.[223] Most forensic techniques remain largely untested and their validity under *Daubert* is questionable at best. Yet they are continually admitted, often based on their long history of judicial acceptance[224] and sometimes by judicial notice.[225] The need for genuine evidentiary analysis grows stronger as an increasing number of convictions, which relied heavily on forensic individualization evidence, are overturned by DNA exonerations.[226] According to Professor David Faigman, "faulty forensic science is second only to eyewitness errors as the leading cause of erroneous convictions."[227]

For example, in 1998, Stephan Cowans was convicted of shooting a Boston police officer.[228] A key item of incriminating evidence offered at trial was a latent fingerprint found at the scene of the shooting.[229] Two separate fingerprint analysts confirmed the match, but the evidence was

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221. FAIGMAN ET AL., *supra* note 192, § 1:35 ("[T]he vitality of *Daubert* itself might be assessed on whether the courts embrace the gatekeeping function seriously enough to challenge forensic scientists to live up to the title 'scientist.'").

222. *Id.*

223. *See, e.g.*, *id.* § 1:30 (noting "courts' general abdication of any serious critical review of the non-DNA forensic identification sciences."); Giannelli, *supra* note 191, at 1111 ("Paradoxically, and perhaps shamefully, [*Daubert*] has not been consistently imposed in criminal cases.").

224. NRC REPORT, *supra* note 166, at 106–09; *see, e.g.*, United States v. Pena, 586 F.3d 105, 110 (1st Cir. 2009) (admitting fingerprint evidence despite the court's reservations about its reliability because "the case law is overwhelmingly in favor of admitting fingerprint experts under virtually any circumstance"); United States v. Prime, 431 F.3d 1147, 1154 (9th Cir. 2005) (same for handwriting identification); United States v. Crisp, 324 F.3d 261, 268 (4th Cir. 2003) (same); FAIGMAN ET AL., *supra* note 192, § 33:3 (describing how judges are convinced of the reliability of fingerprint analysis and avoid conducting a *Daubert* analysis); *see also* D. Michael Risinger, *Cases Involving the Reliability of Handwriting Identification Expertise Since the Decision in* Daubert, 43 TULSA L. REV. 477, 561 (2007) (noting that cases are decided by "authority and case citations," often foregoing the proper admissibility analyses and instead admitting evidence by stare decisis).

225. *See, e.g.*, United States v. Janis, 387 F.3d 682, 689–90 (8th Cir. 2004) (suggesting that fingerprint evidence can be admitted by judicial notice); Brooks v. State, 748 So. 2d 736, 746–47 (Miss. 1999) (Smith, J., concurring) (citing numerous cases where the court took judicial notice of forensic odontology—expert analysis of bite marks—without conducting any evidentiary hearing under either *Frye* or *Daubert*).

226. *See* FAIGMAN ET AL., *supra* note 192, § 1:35. As of February 1, 2009, the Innocence Project has found that "[o]f the first 225 wrongful convictions overturned by DNA testing, more than 50% (116 cases) involved unvalidated or improper forensic science." *See Wrongful Convictions Involving Unvalidated or Improper Forensic Science that Were Later Overturned Through DNA Testing*, THE INNOCENCE PROJECT, http://www.innocenceproject.org/docs/DNA_Exonerations_Forensic_Science.pdf.

227. FAIGMAN ET AL., *supra* note 192, § 1:35.

228. Cowans v. City of Boston, No. 05-CV-11574, 2007 WL 28419, at *1 (D. Mass. Jan. 4, 2007).

229. *Id.*

never challenged under *Daubert*.[230] Six years later, DNA test results showed that the prints were wholly inconsistent with Cowans' DNA profile.[231] The fingerprints were reanalyzed and the initial conclusions were found to be not only erroneous, but it was discovered that the conclusions were known to be erroneous during Cowans' trial and during his conviction, though that information was intentionally concealed.[232] While the unfortunate experience of Stephan Cowans is an extreme example of prosecutorial misconduct, it highlights the importance of conducting a *Daubert* analysis for forensic individualization evidence, and the severe consequences that might accompany a failure to do so. A recent governmental report sums up this point: "[B]ecause accused parties in criminal cases are convicted on the basis of testimony from forensic science experts, much depends upon whether the evidence offered is reliable."[233]

2. Evidentiary Challenges Post-*Daubert*

The rate of pretrial challenges to forensic evidence admissibility has generally increased post-*Daubert*, but most of these challenges occur in civil suits.[234] In criminal trials, prosecutors introduce far more forensic evidence than do defendants, and prosecutors also challenge the admissibility of forensic evidence approximately three-and-a-half times more often than defendants.[235]

The success rate of admissibility challenges to forensic evidence in criminal prosecutions mirrors the disparity with which they are brought. Defendant-initiated *Daubert* challenges succeed less than 10 percent of the time.[236] Challenges by prosecutors, in contrast, succeed more than two-thirds of the time.[237] Although this does not necessarily reflect an inherent unfairness in the judicial system or call into question the wisdom of any

230. *Id.*; Brief for the Innocence Project, Inc. as Amici Curiae Supporting Petitioner, Holmes v. South Carolina, 547 U.S. 319 (2006) (No. 04-1327), 2005 WL 879501, at *13–14 [hereinafter Innocence Project Brief]; Jonathan Saltzman & Mac Daniel, *Man Freed in 1997 Shooting of Officer: Judge Gives Ruling After Fingerprint Revelation*, BOS. GLOBE, Jan. 24, 2004, at A1.

231. Innocence Project Brief, *supra* note 230, at *14.

232. *Cowans*, 2007 WL 28419, at *1; Innocence Project Brief, *supra* note 230, at *13–14.

233. *See* NRC REPORT, *supra* note 166, at 109.

234. FAIGMAN ET AL., *supra* note 192, § 1:35.

235. *Id.*

236. *Id.*

237. *Id.*; *see* Cooley & Oberfield, *supra* note 217, at 285, 291 (finding that the prosecution's success rate is much higher). The disparity is emphasized when compared with *Daubert* challenges to forensic evidence in civil trials. In federal civil trials, forensic evidence was excluded under *Daubert* 41 percent of the time, compared with 25 percent of the time pre-*Daubert*. Challenges made by defendants succeed approximately two-thirds of the time, compared with a success rate of less than half for challenges posed by plaintiffs. FAIGMAN ET AL., *supra* note 192, § 1:35; *see also* Michael L. Perlin, *"His Brain Has Been Mismanaged with Great Skill": How Will Jurors Respond to Neuroimaging Testimony in Insanity Defense Cases?*, 42 AKRON L. REV. 885, 906–07 & 907 n.139 (2009). These statistics underscore the observation that "courts have been, at best, lackadaisical and, at worst, disingenuous in carrying out their gatekeeping duties toward forensic science [in criminal cases]." *See* FAIGMAN ET AL., *supra* note 192, § 1:30.

specific court decision, it has raised eyebrows within the scholarly community.[238]

3. 2009 National Research Council Report

The limitations of the forensic individualization sciences have not gone unnoticed. Recognizing a dire need for improvement, Congress passed the Science, State, Justice, Commerce, and Related Agencies Appropriations Act of 2006.[239] Given the significant "absence of data" within the forensic science and legal communities, the statute authorized the National Academy of Sciences (NAS) to conduct a comprehensive study on the forensic sciences and to suggest improvements and guidelines to "help ensure quality and consistency in the use of forensic technologies."[240]

In its report, the National Research Council (NRC), an arm of the NAS, identified numerous weaknesses plaguing the forensic sciences, of which the most prevalent weaknesses were among forensic individualization sciences.[241] The weaknesses identified by the committee include disparity in operation, inconsistent practices, lack of standardization, absence of certification and accreditation, and interpretive problems.[242] The committee also noted that, except for DNA analysis, no forensic technique has rigorously drawn a consistent and reliable connection between forensic evidence and a specific individual or source.[243]

The committee found that no standardization or regulation exists either across the forensic individualization disciplines or within a particular discipline.[244] The committee further noted that forensics are most often based on subjective interpretations of observed characteristics rather than scientific studies to determine their validity, and that this is "a serious problem."[245] Accordingly, the committee declared that "research is required to establish the limits and measures of performance" of the individualization sciences.[246] Given that the legal and judicial communities rely so heavily on forensics, the committee lamented that "the law's greatest dilemma . . . [is] whether—and to what extent—there is *science* in any given forensic science discipline."[247] The committee made multiple recommendations to improve forensic science evidence in courtrooms, but its initial and primary recommendation was that Congress should

238. *See, e.g.*, FAIGMAN ET AL., *supra* note 192, § 1:35 (offering possible explanations for this disparity); Perlin, *supra* note 237, at 906–07; Saks, *supra* note 206, at 335–41 (explaining why courts accept forensic evidence despite its lack of validity).

239. Pub. L. No. 109-108, 119 Stat. 2290 (codified as amended in scattered sections of 42 U.S.C. and 15 U.S.C.).

240. S. REP. NO. 109-88, at 46 (2005).

241. *See* NRC REPORT, *supra* note 166, at 6.

242. *Id.* at 5–8.

243. *See id.* at 7; *supra* note 206 and accompanying text. *But see supra* note 215 (noting deficiencies in DNA analysis).

244. NRC REPORT, *supra* note 166, at 7.

245. *Id.* at 8.

246. *Id.*

247. *Id.* at 9.

appropriate funds to establish an independent federal entity to supervise, promote, and develop the forensic disciplines into a mature and reliable field of research and practice.[248]

4. Forensic Individualization in the Courtroom

Various courts, including the Supreme Court,[249] have admitted forensic individualization evidence despite recognizing that it has significant weaknesses.[250] While some courts appear to conduct a *Daubert* analysis, they overlook scientific issues and admit the evidence on non-scientific grounds, often yielding to its history of past admissibility.[251] For example, in *United States v. Crisp*,[252] the Fourth Circuit found that both fingerprint identification and handwriting comparison survive *Daubert*.[253] Although the court appeared to conduct a *Daubert* analysis,[254] it explicitly stated its reason for admitting the testimony: "[L]ike fingerprint analysis, handwriting comparison testimony has a long history of admissibility in the courts of this country. The fact that handwriting comparison analysis has achieved widespread and lasting acceptance in the expert community gives us the assurance of reliability that *Daubert* requires."[255] The court recognized the scientific shortcomings of the evidence[256] and noted that a few district courts had recently questioned its viability under *Daubert*.[257]

248. *Id.* at 81–82.

249. *See* Melendez-Diaz v. Massachusetts, 129 S. Ct. 2527, 2537 (2009) (noting that although there are "[s]erious deficiencies" in the forensic evidence used in criminal trials, confrontation and the adversarial process can weed them out).

250. *See, e.g.*, United States v. Berry, 624 F.3d 1031, 1041, 1043 (9th Cir. 2010) (noting serious criticisms of lead bullet forensic analysis are "no more than impeaching evidence"); United States v. Ford, 481 F.3d 215, 218 n.5 (3d Cir. 2007) (admitting forensic individualization evidence but noting that *Daubert* "might be a fruitless exercise" due to "some of the difficulties inherent in this type of science"); United States v. Crisp, 324 F.3d 261, 270 (4th Cir. 2003) (noting that while additional research "would be welcome," it would be foolish to exclude the evidence); United States v. Willock, 696 F. Supp. 2d 536, 568 (D. Md. 2010) (finding that although forensic toolmark analysis may not be "sufficiently reliable to be called a 'science,'" it is consistently admitted and may still be useful to the jury); *see also* FAIGMAN ET AL., *supra* note 192, § 1:30 ("Although the scholarly literature is increasingly demonstrating the paucity of data underlying many forensic fields, courts blithely ignore the empirical realities.").

251. *See, e.g.*, United States v. Prime, 431 F.3d 1147, 1154 (9th Cir. 2005) (holding that district court's finding that handwriting testimony was admissible "was consistent with all six circuits that have addressed [its] admissibility"); United States v. Rogers, 26 F. App'x 171, 173 (4th Cir. 2001) ("[V]irtually every circuit and district court, both before and after *Daubert*, [has] a longstanding tradition of allowing fingerprint examiners to state their opinion and conclusions.").

252. 324 F.3d 261 (4th Cir. 2003).

253. *Id.* at 271.

254. *Id.* at 265–68.

255. *Id.* at 271 (citation omitted). *But see id.* at 272 (Michael, J., dissenting) (describing how a long history of admissibility should not grant the government a "pass" to show how the evidence satisfies *Daubert*).

256. *Id.* at 270 ("[F]urther research into fingerprint analysis would be welcome.").

257. *Id.* at 270 n.5.

Yet in what one scholar calls a "breathtaking[] disregard of *Daubert*,"[258] the court nevertheless was unwilling to depart from the pedigree of the evidence.[259] As some scholars note, the court blindly accepted the validity of the evidence, stating that its error rate was "negligible" or "essentially zero,"[260] a statement that is "startling" when given without supporting data.[261]

Similarly, in *Green*, Judge Nancy Gertner strongly implied that expert toolmark testimony[262] should properly be excluded under *Daubert*,[263] but that she felt "compelled to allow" it because she was "confiden[t] that any other decision will be rejected by appellate courts, in light of precedents across the country" that consistently admit it.[264] Judge Gertner expressed her frustration with the testimony's continued admission despite its obvious *Daubert* insufficiencies, lamenting: "The more courts admit this type of toolmark evidence without requiring documentation, proficiency testing, or evidence of reliability, the more sloppy practices will endure; we should require more."[265]

A recent district court opinion struck a different chord. In *United States v. Willock*,[266] Judge William D. Quarles, Jr. adopted the report and recommendation of Magistrate Judge Paul W. Grimm, who conducted an extensive *Daubert* review of ballistics identification.[267] Noting that the validity of the science "has not yet been fully demonstrated," Judge Grimm found that the expert's testimony still had a "baseline level of credibility" useful to the jury[268] and should be admitted under *Daubert*, but with strict qualifications.[269] The court allowed the expert to testify in uncertain terms—using the qualifying phrase, "more likely than not"[270]—and mandated that the testimony was to be considered an "estimate" supported by the evidence, which would go to the weight of the testimony.[271] The jury would reach the ultimate question of whether the bullets were fired

258. FAIGMAN ET AL., *supra* note 192, § 34:7 (referring to the court's decision to admit the evidence as adopting the "guild test," meaning that courts defer to the history of the evidence's use in court); *see* NRC REPORT, *supra* note 166, at 110 (noting that judges could be reluctant to conduct proper *Daubert* analyses due to history of admissibility); *see also* United States v. Baines, 573 F.3d 979, 992 (10th Cir. 2009) (holding that fingerprint evidence survives *Daubert*, largely due to its history of admissibility).

259. *Id.* at 270 ("[L]ike fingerprint analysis, handwriting comparison testimony has a long history of admissibility in the courts of this country.").

260. FAIGMAN ET AL., *supra* note 192, § 34:7 (citing *Crisp*, 324 F.3d at 269).

261. *See id.* § 33:18; *see also* NRC REPORT, *supra* note 166, at 142 ("[C]laims . . . [of] zero error rates are not scientifically plausible.").

262. Toolmarks are generated when a hard object comes into contact with a relatively softer object, leaving an indentation or marking which experts can trace to an individual tool. *See* NRC REPORT, *supra* note 166, at 150.

263. United States v. Green, 405 F. Supp. 2d 104, 109 (D. Mass. 2005).

264. *Id.* at 108–09.

265. *Id.* at 109.

266. 696 F. Supp. 2d 536 (D. Md. 2010).

267. *Id.* at 549–74.

268. *Id.* at 570.

269. *Id.* at 547 nn.25–26.

270. *Id.* at 574.

271. *Id.*

from the specific firearm.[272] Responding to concerns about the unreliability of the testimony or its potential to mislead the jury, Judge Quarles said those weaknesses would emerge "through effective cross-examination, or by offering defense experts to challenge [them]."[273]

With the exception of some recent district court decisions,[274] most courts do not question forensic individualization evidence under *Daubert*, and some argue that to do so would "make the best the enemy of the good."[275] Some commentators agree, suggesting that unreliable forensic evidence is admitted because to "demand more by way of validation [is more] than the disciplines can presently offer."[276] Others voice their disagreement by suggesting that forensic evidence is admitted under a misguided understanding of the *Daubert* "reliability" requirement as expressed in Rule 702.[277] As will be discussed in Part III.A, the fact that individualization evidence is routinely admitted under *Daubert* without subjecting it to a proper admissibility analysis should force judges to carefully consider admitting functional neuroimaging evidence.

II. ADMISSIBILITY OF FUNCTIONAL NEUROIMAGING

This part discusses the arguments for and against admitting functional brain scans as evidence in the courtroom. This Note avoids potential constitutional issues posed by such evidence[278] and focuses instead on federal criminal cases in which such evidence is used, admissibility issues raised under the federal evidence admissibility standards, and implications of such evidence for the criminal justice system at the federal level.

While courts are quick to admit neuroscience evidence,[279] courts have been more circumspect about admitting functional neuroimaging

272. *See id.* at 573–74.

273. *Id.* at 578.

274. *See, e.g.*, Deputy v. Lehman Bros., 345 F.3d 494, 509 (7th Cir. 2003) (citing several district courts that have rejected handwriting analysis for lack of scientific reliability); United States v. Taylor, 663 F. Supp. 2d 1170, 1180 (D.N.M. 2009) (finding ballistics was not a science but admitting the testimony with similar qualifications); United States v. Glynn, 578 F. Supp. 2d 567, 574–75 (S.D.N.Y. 2008) (same); *see also supra* note 194.

275. United States v. Baines, 573 F.3d 979, 992 (10th Cir. 2009); United States v. Crisp, 324 F.3d 261, 270 (4th Cir. 2003); *see also* United States v. Mitchell, 199 F. Supp. 2d 262, 267 n.5 (E.D. Pa. 2002); United States v. Llera-Plaza, 188 F. Supp. 2d 549, 572 (E.D. Pa. 2002).

276. NRC REPORT, *supra* note 166, at 109 (citing *Crisp*, 324 F.3d at 270); Joan Griffin & David J. LaMagna, Daubert *Challenges to Forensic Evidence: Ballistics Next on the Firing Line*, CHAMPION MAG., Sept.–Oct. 2002, at 20.

277. *See, e.g.*, Dale A. Nance, *Reliability and the Admissibility of Experts*, 34 SETON HALL L. REV. 191, 193–219 (2003) (discussing general reliability standard and how it has been misapplied).

278. For example, constitutional issues are raised if scans are used as lie detection devices. *See, e.g.*, John G. New, *If You Could Read My Mind: Implications of Neurological Evidence for Twenty-First Century Criminal Jurisprudence*, 29 J. LEGAL MED. 179, 193–98 (discussing Fourth and Fifth Amendment concerns raised by neurologically-based lie detection devices). *See generally* Stoller & Wolpe, *supra* note 115 (discussing Fourth and Fifth Amendment implications).

279. *See, e.g.*, Moriarty, *supra* note 71, at 31 (noting that structural brain scans "are routinely introduced in court to show brain injuries, tumors, and abnormalities"); Patel et al.,

evidence.[280] Functional neuroimaging is "too new, too uncertain, and too laden with troubling questions to earn easy admission to the courts."[281] Further, most of the criminal cases in which functional neuroimaging evidence is admitted are state cases, not federal, though it has been admitted in civil litigation at both the state and federal level.[282]

A. Arguments for Excluding Functional Neuroimaging Evidence

1. Lack of Methodological and Interpretive Standardization

Critics question the validity and reliability of the underlying science of functional neuroimaging,[283] and often refer to an analytical or deductive gap between the imaging studies and the courtroom testimony.[284] As noted earlier, neuroimaging techniques have either a temporal delay or imperfect spatial resolution, or a combination of both.[285] Critics argue that courtroom use is premature because the scans necessarily involve expert interpretations,[286] which depend heavily on the methods employed by the individual scientists and researchers conducting the scans.[287] Individual assumptions, they argue, can influence the results of a scan because numerous choices and considerations contribute to determining how the scans will be conducted, what data will be collected, and how that data will be analyzed.[288] As the studies get more complex, so does the data, which in turn increases the subjectivity and disparity in interpreting the results.[289] With little standardization among neuroimaging techniques, it is difficult to compare objectively the results of a scan conducted by one researcher with those of another scan conducted by a different researcher.[290]

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supra note 33, at 557–58 (noting that brain imaging is used "[i]n courthouses across the United States").

280. *See* Moriarty, *supra* note 71, at 29, 32, 48 (noting that few courts have admitted fMRI-based evidence). While Yang and colleagues state that approximately 130 cases have utilized PET or SPECT scans, they do not break down the distribution of cases into state and federal, or civil and criminal. *See* Yang et al., *supra* note 48, at 77–78.

281. Moriarty, *supra* note 71, at 48.

282. *See* Patel et al., *supra* note 33, at 561–64 (describing the types of cases in which functional neuroimaging evidence has been admitted).

283. *See, e.g.*, Jay D. Aronson, *The Law's Use of Brain Evidence*, 6 ANN. REV. L. SOC. SCI. 93, 100–01 (2010); Khoshbin & Khoshbin, *supra* note 22, at 171–72; Jennifer Kulynych, Note, *Psychiatric Neuroimaging Evidence: A High-Tech Crystal Ball?*, 49 STAN. L. REV. 1249, 1259 (1997).

284. *See, e.g.*, Kulynych, *supra* note 283, at 1259.

285. *See supra* notes 61, 70–71, 77–79, 89–91 and accompanying text (describing various neuroimaging techniques and their corresponding temporal and/or spatial resolution).

286. Kulynych, *supra* note 283, at 1259; *See* Brown & Murphy, *supra* note 54, at 1149–52 (discussing the problems of individual differences as they pertain to fMRI lie detection); Greely, *supra* note 6, at 711–14; Reeves et al., *supra* note 63, at 90.

287. Baskin et al., *supra* note 45, at 249; Brown & Murphy, *supra* note 54, at 1142–43.

288. *See* Brown & Murphy, *supra* note 54, at 1143–49, 1152–55; Feigenson, *supra* note 89, at 32; Greely & Illes, *supra* note 90, at 383–84; Jones et al., *supra* note 62, ¶ 32.

289. Baskin et al., *supra* note 45, at 249; Brown & Murphy, *supra* note 54, at 1144–49.

290. *See* Brown & Murphy, *supra* note 54, at 1143, 1152–55 (discussing variables in methods used); Snead, *supra* note 45, at 1288–89; *see also* Jackson v. Calderon, 211 F.3d 1148, 1165 (9th Cir. 2000) (upholding district court's exclusion of defendant's PET scan in

Critics also argue that individual differences among subjects are important in law, and functional neuroimaging insufficiently accounts for them.[291] Thresholds demarcating statistically significant brain activity[292] are not standardized, so deviation from arbitrarily established norms may not reliably indicate whether a subject has normal or dysfunctional brain activity.[293] As one scholar noted, "Anyone dealing with the application of neuroscience to law has to remember that most studies are about group averages, but there is no 'group' in the witness box or the defendant's seat. Moving from the group average to the individual will be very hard."[294] The brain is a composite of influences incorporating numerous social, cultural, and personal experiences.[295] When introduced in legal settings such as courtrooms, these individual characteristics and unique qualities are prioritized and they become exceedingly important, so even the slightest nuances in brain function are highly relevant.[296] Basing comparisons and results on arbitrarily established "normal" levels as is the case with functional neuroimaging is therefore unhelpful.[297]

2. Complexity and Interconnectedness of the Brain

Furthermore, critics oppose functional neuroimaging evidence because even if scans can accurately detect specific patterns of brain activity in individuals, the brain is too complex to localize behavior to a specific brain region.[298] Moreover, critics argue that scientists can only draw correlations between brain function and human behavior; direct causation cannot be traced.[299] With the interconnectedness between brain regions and brain

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part because it "is susceptible to conflicting interpretations"), *aff'd after new sentencing hearing sub nom.* People v. Jackson, 199 P.3d 1098 (Cal. 2009).

291. Brown & Murphy, *supra* note 54, at 1150–52; Greely, *supra* note 6, at 713–14.

292. *See supra* notes 62–65 and accompanying text (discussing how functional neuroimaging relies on comparisons based on comparing a subject's brain activity with previously collected "normal" activity).

293. *See* Brown & Murphy, *supra* note 54, at 1150 (noting the importance of individual differences and their ability to skew results); Greely, *supra* note 6, at 714; Greely & Illes, *supra* note 90, at 380–81 (describing numerous reasons why deviations in results may occur).

294. Greely, *supra* note 6, at 714; *see also* Brown & Murphy, *supra* note 54, at 1150–52.

295. *See* Goodenough & Tucker, *supra* note 57, at 66.

296. *See* Greely, *supra* note 6, at 713–14 (describing how variations occur across individuals, and "as the law mainly cares about individuals, this is a real challenge").

297. *See id.*; *see also* Brown & Murphy, *supra* note 54, at 1150–52 (noting the importance of individual differences).

298. *See* Steven K. Erickson, *Blaming the Brain*, 11 MINN. J. L. SCI. & TECH. 27, 32 (2010) ("Brain activity is a global phenomenon, not merely a localized one within compartments of the brain . . . ."); Amanda C. Pustilnik, *Violence on the Brain: A Critique of Neuroscience in Criminal Law*, 44 WAKE FOREST L. REV. 183, 219–26 (2009) (describing the difficulty of localizing behavior to specific brain regions); Snead, *supra* note 45, at 1287–88 & 1287 n.110 (same).

299. Baskin et al., *supra* note 45, at 249; Jones et al., *supra* note 62, ¶ 38; Snead, *supra* note 45, at 1287.

function insufficiently understood, the risk of error in reaching legal conclusions based on inferences about brain function is high.[300]

3. Minimal Probative Value

Even if functional brain scans can accurately associate brain function with activity in a specific area of the brain, critics are not convinced that such findings would have probative value to "assist" the fact-finder as Rule 702 requires.[301] As Professor Michael Gazzaniga argues, law is concerned with individual actions and responsibility, a social-legal construct that "does not exist in the neuronal structures of the brain."[302] Functional neuroimaging is therefore unhelpful unless it can provide "actual proof that the defendant is unable to appreciate the nature and quality or the wrongfulness of his acts."[303] Compounding this difficulty, current neuroimaging techniques measure brain activity indirectly, either by blood flow, metabolic activity, or electrical signals, and are thus "necessarily attenuated from the ultimate object of interest—namely, cognitive function."[304] Critics therefore oppose admitting functional neuroevidence about a defendant's inability to have formed the requisite intent to commit a crime.[305]

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300. Aronson, *supra* note 283, at 94 ("We simply do not yet have the technology or the understanding to link the brain structure and activity to behavior in any legally meaningful way."); Snead, *supra* note 45, at 1288.

301. *See, e.g.*, Goodenough & Tucker, *supra* note 57, at 72; *see also* FED. R. EVID. 702; Johnson, *supra* note 55, at 30–32; Stephen J. Morse, *Brain Overclaim Syndrome and Criminal Responsibility: A Diagnostic Note*, 3 OHIO ST. J. CRIM. L. 397, 406 (2006) (arguing that the criteria for criminal responsibility are normative and neuroscience is unhelpful to the jury); Walter Sinnott-Armstrong et al., *Brain Images as Legal Evidence*, 5 EPISTEME 359, 362–67 (2008).

302. GAZZANIGA, *supra* note 55, at 102; *see also* Morse, *supra* note 301, at 400.

303. Moriarty, *supra* note 71, at 42. Many scholars debate this issue at length, and legal-philosophical implications about free will and determinism abound. *See, e.g.*, GAZZANIGA, *supra* note 55, at 87–102; Lisa Claydon, *Mind the Gap: Problems of Mind, Body and Brain in the Criminal Law*, *in* LAW, MIND AND BRAIN, *supra* note 57, at 55, 55–80; Michael S. Gazzaniga & Megan S. Steven, *Free Will in the Twenty-first Century: A Discussion of Neuroscience and the Law*, *in* NEUROSCIENCE AND THE LAW, *supra* note 113, at 51, 51–70; Dean Mobbs et al., *Law, Responsibility, and the Brain*, *in* LAW, MIND AND BRAIN, *supra* note 57, at 5, 5–22; Stephen J. Morse, *New Neuroscience, Old Problems*, *in* NEUROSCIENCE AND THE LAW, *supra* note 113, at 157, 157–98. Professor Stephen Morse has coined this the "psycholegal error," which is the tendency to think that an actor is not responsible for his actions due to his genes or his brain function. Stephen J. Morse, *Criminal Responsibility and the Disappearing Person*, 28 CARDOZO L. REV. 2545, 2569 (2007). *But see* Joshua Greene & Jonathan Cohen, *For the Law, Neuroscience Changes Nothing and Everything*, *in* LAW & THE BRAIN, *supra* note 40, at 207 (offering a counterargument that although neuroscience may not challenge the law's stated assumptions, it likely will change the way we think about criminal responsibility).

304. Snead, *supra* note 45, at 1288.

305. *See, e.g.*, Brown & Murphy, *supra* note 54, at 1131–32, 1187–88 (arguing that current functional neuroimaging technologies are unable to draw a meaningful conclusion about past mental states); Snead, *supra* note 45, at 1287 & n.110; Kulynych, *supra* note 283, at 1259.

4. Potential to Mislead and Confuse the Jury

Finally, critics argue that functional neuroimaging should be excluded under Rule 403[306] because it can mislead the jury.[307] Even if the actual images are not admitted as evidence, there is concern that any neuroscience-based evidence—either the scans themselves or the expert testimony interpreting those scans—will unduly prejudice or mislead the jury.[308] If the actual scans are presented to a jury, critics fear a "Christmas tree effect," whereby jurors may be so impressed by the visual display of a colorful brain scan that they accept the scan as authoritative evidence without considering the merits of the expert's accompanying testimony.[309] Moreover, jurors might confuse differences in degree for differences in kind, mistaking delicate, nuanced changes in brain activity for a simplified dichotomy indicating that brain activity is present or absent.[310] In other words, a jury might think that a scan irrefutably supports the expert's testimony about a defendant's mental state when in fact it might only suggest the increased likelihood that a defendant either possessed a particular mental state, or that a defendant might not be capable of possessing a particular mental state.[311]

5. Criminal Cases in Which Federal Courts Excluded Functional Neuroimaging Evidence

It is difficult to accurately assess how functional neuroimaging is used in federal litigation because most cases never reach trial, fewer complete a trial, and even fewer are reported.[312] Of those that are reported, only a fraction conduct or record evidentiary hearings.[313] Of the few federal

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306. *See supra* notes 157–59 and accompanying text (discussing Rule 403).

307. *See, e.g.*, Brown & Murphy, *supra* note 54, at 1188–1202; Khoshbin & Khoshbin, *supra* note 22, at 171, 185; Perlin, *supra* note 237, at 891–92; Reeves et al., *supra* note 63, at 89; Shafi, *supra* note 72, at 30; Kulynych, *supra* note 283, at 1262.

308. *See* Sinnott-Armstrong et al., *supra* note 301, at 368–69 (discussing concerns of "neurobabble"); Deena Skolnick Weisberg et al., *The Seductive Allure of Neuroscience Explanations*, 20 J. COGNITIVE NEUROSCIENCE 470, 476–77 (2008) (finding that evidence supported by neuroscience explanations is more convincing to the lay person than the same evidence without neuroscience explanation).

309. Brown & Murphy, *supra* note 54, at 1190–91; Goodenough & Tucker, *supra* note 57, at 72.

310. *See* Goodenough & Tucker, *supra* note 57, at 72; *see also* Snead, *supra* note 45, at 1289–90.

311. *See* Eric Bailey, *Defense Probing Brain to Explain Yosemite Killings*, L.A. TIMES, June 15, 2000, at A3 ("Jurors can be dazzled by the display. Christopher Plourd, a San Diego criminal defense attorney, remembers well the first time he used PET scans in the early 1990s during a murder trial. 'Here was this nice color image we could enlarge, that the medical expert could point to,' Plourd said. 'It documented that this guy had a rotten spot in his brain. The jury glommed onto that.'").

312. Snead, *supra* note 45, at 1291.

313. *See* United States v. Montgomery, 635 F.3d 1074 (8th Cir. 2011); United States v. Puerto, No. 07-14097, 2010 WL 3191765 (11th Cir. Aug. 12, 2010); Jackson v. Calderon, 211 F.3d 1148 (9th Cir. 2000), *aff'd after new sentencing hearing sub nom.* People v. Jackson, 199 P.3d 1098 (Cal. 2009); United States v. Mezvinsky, 206 F. Supp. 2d 661 (E.D. Pa. 2002); United States v. Gigante, 982 F. Supp. 140 (E.D.N.Y. 1997), *aff'd*, 166 F.3d 75

criminal cases that have conducted *Daubert* analyses, most have excluded functional neuroimaging evidence and its corresponding testimony due to unreliability[314] or irrelevance,[315] or the courts found that it had minimal probative value because the evidence could not accurately assess a defendant's past mental state.[316]

In *United States v. Mezvinsky*,[317] PET scan evidence was introduced to show that the defendant, who was accused of multiple counts of fraud, was incapable of intentionally deceiving a person or institution, which was the requisite mens rea for his crime.[318] The district court found the scans unhelpful and irrelevant since they could not provide concrete information concerning the defendant's capacity to deceive.[319] Accordingly, the PET scans were inadmissible for lack of reliability and for irrelevance to the specific legal question at issue.[320]

Similarly, in *United States v. Puerto*,[321] the Eleventh Circuit affirmed the lower court's decision to exclude the defendant's expert under a *Daubert* analysis.[322] In an attempt to demonstrate that the defendant could not have formed the mens rea necessary for fraud and money laundering, the defendant sought to introduce expert testimony about his diagnoses of progressive vascular dementia.[323] The defendant wanted to show a brain scan indicating that a region of his brain was "cavitated out" and the brain tissue was replaced by fluid, indicating damage to numerous brain functions, including comprehension and executive planning.[324] The defendant also sought to introduce an EEG scan to pinpoint the causes of the dementia.[325] The district court excluded the testimony and the neuroimaging evidence under *Daubert* and Rule 702 for lack of relevance.[326] The Eleventh Circuit affirmed, finding that the experts were unable to testify "with any medical certainty" that the defendant lacked the requisite intent at the time of the offenses and that the evidence could not

(2d Cir. 1999); *see also* United States v. Sandoval-Mendoza, 472 F.3d 645 (9th Cir. 2006) (holding that neuroimaging evidence which could elucidate nature of defendant's brain function was improperly excluded); United States v. Williams, No. CR 06-00079, 2009 WL 424583 (D. Haw. Feb. 20, 2009) (noting "considerable debate exists" about the reliability of functional neuroimaging, but entertaining the thought that it could be relevant).

314. *See, e.g.*, *Gigante*, 982 F. Supp. at 147–48 (finding that the scans were "dubious, based upon speculative scientific theories lacking full development" and the "opinions of [the] defendant's experts were unreliable").

315. *See Mezvinsky*, 206 F. Supp. 2d at 674–75; *Puerto*, 2010 WL 3191765, at *13.

316. *See Mezvinsky*, 206 F. Supp. 2d at 674–75; *Puerto*, 2010 WL 3191765, at *13.

317. 206 F. Supp. 2d 661 (E.D. Pa. 2002).

318. *Id.* at 667–69.

319. *Id.* at 675 ("[T]here is . . . no evidence that Mezvinsky's PET-identified brain abnormalities had any pertinence to his capacity to deceive . . . .").

320. *Id.* The prosecution argued that the PET scans could mislead and confuse the jury and should be excluded under Rule 403. The court, however, did not reach that question in its analysis. *See id.*

321. No. 07-14097, 2010 WL 3191765 (11th Cir. Aug. 12, 2010).

322. *Id.* at *12–13.

323. *Id.* at *9–10.

324. *Id.* at *10.

325. *Id.*

326. *Id.* at *13.

"help the jury decide a factual dispute."[327] In both *Mezvinsky* and *Puerto*, functional brain scans were excluded under *Daubert* for lack of relevance.[328]

B. Arguments for Admitting Functional Neuroimaging Evidence

Although many scholars and commentators oppose introducing functional neuroimaging into the courtroom,[329] others advocate for its admission.[330] This section discusses arguments in favor of admitting functional neuroimaging. Proponents argue that functional neuroimaging evidence may be sufficiently reliable,[331] relevant, and useful,[332] and that its probative value outweighs the risk of prejudicing or misleading the jury.[333]

1. Criticism Is Not Based on Legal Doctrine

Substantial research supports the notion that functional brain scans reliably report on brain function,[334] but the legal community has been slow to accept this. Some contend that the legal community's reluctance to embrace functional neuroimaging is not so much about the substance of the science as it is an unwillingness or hesitance to build a collaborative bridge between science and the law.[335] Professor Oliver Goodenough and Vermont Assistant Attorney General Micaela Tucker suggest that lawyers are "too bound by current paradigms to see the leaps that could be made in doctrine and practice"[336] by incorporating scientific findings into the legal arena. Resistance to neuroimaging evidence, they argue, may be based more on intransigence than on legal doctrine.[337]

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327. *Id.*

328. *See id.*; *United States v. Mezvinsky*, 206 F. Supp. 2d 661, 677 (E.D. Pa. 2002); *see also* Trapp v. Spencer, 479 F.3d 53, 58, 62–63 (1st Cir. 2007) (affirming denial of habeas petition seeking new PET scan results in part because the brain scan was conducted twenty years after the murder and may not have been representative of the defendant's brain condition when the defendant committed the crime).

329. *See supra* Part II.A.1.

330. *See, e.g.*, Feigenson, *supra* note 89, at 44–48; Goodenough & Tucker, *supra* note 57, at 80–82; Johnson, *supra* note 55, at 39–40; Yang et al., *supra* note 48, at 79–80; *see also* Beecher-Monas & Garcia-Rill, *supra* note 106, at 261. *See generally* Kittay, *supra* note 115.

331. *See, e.g.*, Frederick Schauer, *Can Bad Science Be Good Evidence? Neuroscience, Lie Detection, and Beyond*, 95 CORNELL L. REV. 1191, 1205–06 (2010).

332. *See, e.g.*, Goodenough & Tucker, *supra* note 57, at 80; Erin Ann O'Hara, *How Neuroscience Might Advance the Law*, *in* LAW & THE BRAIN, *supra* note 40, 21, 27–31; Shafi, *supra* note 72, at 29–30.

333. *See, e.g.*, Feigenson, *supra* note 89, at 44–45, 48.

334. *See generally* Fabian, *supra* note 106; Raine, *supra* note 109; Raine & Yang, *supra* note 106; Sapolsky, *supra* note 40; Robert W. Thatcher et al., *Quantitative EEG and the* Frye *and* Daubert *Standards of Admissibility*, 34 CLINICAL ELECTROENCEPHALOGRAPHY 1 (2003) (arguing that qEEG is sufficiently reliable to pass evidentiary standards).

335. *See* Goodenough & Tucker, *supra* note 57, at 80.

336. *Id.* at 82; *see also* Pettit, Jr. *supra* note 74, at 340 (concluding that brain imaging is constantly evolving and, should brain imaging reach the point of admissibility, courts should be open to this new form of evidence "even if the result is a profound transformation of how [our legal system] operates").

337. Goodenough & Tucker, *supra* note 57, at 80–82.

2. Functional Neuroimaging Is Sufficiently Reliable to Pass *Daubert*

Responding to critics' concerns about experts' use of probability and inference when interpreting functional neuroimaging,[338] Professors Erica Beecher-Monas and Edgar Garcia-Rill concede that the testimony is necessarily couched in terms of probability, inference, and correlation rather than certainty.[339] They argue that this is standard scientific practice: causality cannot be determined with certainty, so probability and inference are necessary to reach conclusions.[340] Using probability and inference "do[es] not . . . make [the observations] useless or unrealistic."[341] Beecher-Monas and Garcia-Rill argue that when judges act as gatekeepers, they must allow for the "probabilistic nature of science" when considering the admissibility of functional neuroimaging evidence.[342] Echoing *Daubert*, they argue that the judge's role as gatekeeper is not to decide whether the proposed scientific theory is correct, but only to determine whether it meets the criteria qualifying it as a "sound science."[343] So long as the proffered testifying experts can present their opinions with sufficient supporting data and explain how the hypotheses were tested while accounting for conflicting opinions in true scientific fashion, functional neuroimaging meets *Daubert* standards and should be admitted.[344]

3. Excluding Functional Brain Imaging Would Deny Defendants Their "Right to Voice"

Defendants would be more likely than prosecutors to introduce functional neuroimaging evidence, primarily about past mental states.[345] Proponents argue that excluding such evidence would deprive defendants of their right to testify on their own behalf, coined by one scholar as a defendant's "right to voice."[346] In *Rock v. Arkansas*,[347] the Supreme Court affirmed a

338. *See supra* Part II.A.1–2.

339. *See* Beecher-Monas & Garcia-Rill, *supra* note 106, at 253, 257, 276.

340. *Id.* at 253 ("The probability that one event caused another can be increased or decreased, depending on how well new evidence fits with the guiding theory, but it cannot be determined with absolute certainty."); *see also* Nance, *supra* note 277, at 193 (arguing that courts misunderstand *Daubert*'s reliability requirement and that evidence is not a "binary, all-or-nothing concept of reliability—that evidence is either reliable or unreliable," but that "the reliability of evidence is a matter of degree").

341. Beecher-Monas & Garcia-Rill, *supra* note 106, at 256.

342. *Id.* at 257.

343. *Id.* at 262; *see supra* note 125 and accompanying text.

344. Beecher-Monas & Garcia-Rill, *supra* note 106, at 256, 262, 275–76.

345. Defendants could also introduce such evidence to boost their credibility by attempting to show they are not falsifying their testimony, *see supra* note 115, but that is beyond the scope of this Note.

346. SLOBOGIN, *supra* note 185, at 40, 53–55 (pointing out that when defendants wish to testify on their own behalf, both First and Sixth Amendment protections are triggered). Slobogin notes that a defendant's right to testify is particularly important when the testimony concerns the defendant's mental state. *Id.*; *see* Greely, *supra* note 113, at 131–32 (discussing a constitutional right, based on the Fifth and Sixth Amendments, for criminal defendants to present evidence in their own defense).

347. 483 U.S. 44 (1987).

defendant's right to testify on his or her own behalf, holding that that defendants must be able to present "[their] version of the events for which [they are] on trial" unless they are "so untrustworthy" or "immune to the traditional means of evaluating credibility."[348] Supporters suggest that functional neuroimaging evidence provides experts with scientific facts upon which they can draw inferences "that not only support the defendant's story but may be the only source for it."[349] Excluding such evidence would "deprive the criminal defendant of the voice the Constitution guarantees."[350] Furthermore, with no easy or direct way to assess accuracy about a defendant's past mental state, an expert could offer the judge and jury important information about the defendant based on the expert's professional experience and through the expert's opinion informed by the neuroimaging evidence.[351]

In *United States v. Sandoval-Mendoza*,[352] the Ninth Circuit found that the district court abused its discretion when it excluded the defendant's functional neuroimaging evidence.[353] The court concluded that without the evidence, the jury could not reach a reasonable conclusion about whether the defendant possessed the requisite mental state, whether the defendant was liable, or whether he had a valid defense.[354] Because the district court excluded the evidence, the Ninth Circuit found that he was "'deprived . . . of a fair opportunity to defend himself.'"[355]

4. Functional Brain Imaging Has Probative Value

Proponents also assert that functional neuroimaging evidence is relevant to contested legal questions at trial. Neuroimaging evidence is not a "brain-print in isolation from all other evidence" that independently proves a defendant's guilt or innocence.[356] Rather, it is "one factor among many" that can help the finder of fact reach an informed decision about a defendant's innocence or guilt.[357] For example, such evidence can show that a defendant has impaired brain function, indicating an increased

348. *Id.* at 61.

349. SLOBOGIN, *supra* note 185, at 55; *see also* Beecher-Monas & Garcia-Rill, *supra* note 106, at 261 ("Mental state is such an important facet of our understanding of criminal responsibility that judges need to be open to the new ideas emerging in the field of brain science.").

350. SLOBOGIN, *supra* note 185, at 55.

351. *Id.* at 40, 43–48, 51; Beecher-Monas & Garcia-Rill, *supra* note 106, at 261.

352. 472 F.3d 645 (9th Cir. 2006).

353. *See id.* at 654.

354. *See id.* at 656.

355. *Id.* (quoting *United States v. Slaughter*, 891 F.2d 691, 698 (9th Cir. 1989)).

356. Yang et al., *supra* note 48, at 79.

357. *Id.*; *see also* United States v. Williams, No. CR 06-00079, 2009 WL 424583, at *5–6 (D. Haw. Feb. 20, 2009) (noting that while it is controversial, functional neuroimaging can potentially enlighten the fact-finder on questions of the defendant's mental intent and culpability); Stephen H. Dinwiddie, *Biological Causes of Criminality and Expert Testimony—Some Cautionary Thoughts*, *in* THE SCIENCE, TREATMENT, AND PREVENTION OF ANTISOCIAL BEHAVIORS: APPLICATION TO THE CRIMINAL JUSTICE SYSTEM 24-1, at 24-9 (Diana H. Fishbein ed., 2000); O'Hara, *supra* note 332, at 28–30 (describing neuroscience as a contributing factor that can help the fact-finder decide on ultimate issues of culpability).

likelihood of disinhibition or aggressive behavior.[358] It would be up to the fact-finder to decide how to weigh the evidence or whether to rely on it at all.[359] If the question concerns a defendant's mental state at the time of the incident, functional neuroimaging can help the jury reach an ultimate conclusion about whether the defendant was or was not of a particular frame of mind.[360]

5. Probative Value of Functional Neuroimaging Outweighs Its Prejudicial Risk

Responding to those who wish to exclude functional neuroimaging under Rule 403,[361] proponents assert that such evidence will not overly mislead or prejudice the jury.[362] Others believe that jurors would be no less capable of critically evaluating functional neuroimaging evidence than they would be at critically evaluating other types of scientific evidence.[363] Still others argue that the probative value of the evidence is much too strong to exclude it based on a possible prejudicial effect, and certainly too strong for per se exclusion.[364] Professor Neal Feigenson even suggests that the best way to obtain reliable functional neuroimaging-based testimony and to decrease its prejudicial effect is to admit more of that type of evidence and allow the experts and lawyers to educate the jurors.[365] Professor Feigenson aligns himself with *Daubert* and states that the best way to evaluate the merits of functional neuroimaging evidence is to present competing opinions to argue over the interpretations and results of the brain scans.[366] This, he argues,

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358. *See supra* notes 40, 106 and accompanying text.

359. Dinwiddie, *supra* note 357, at 24-9; *see also* O'Hara, *supra* note 332, at 29–30; Note, *Reliable Evaluation of Expert Testimony*, 116 HARV. L. REV. 2142, 2153 (2003) (noting that jurors should be the arbiters of as-applied reliability).

360. O'Hara, *supra* note 332, at 30.

361. *See supra* notes 157–60 and accompanying text (explaining Rule 403); *supra* Part II.A.4.

362. *E.g.*, Feigenson, *supra* note 89, at 44–48; Goodenough & Tucker, *supra* note 57, at 72 ("[P]otential for prejudice does not make neuroscience evidence inadmissible per se."); Schauer, *supra* note 331, at 1210; Sinnott-Armstrong et al., *supra* note 301, at 370.

363. Perlin, *supra* note 237, at 890 (quoting Dov Fox, *Brain Imaging and the Bill of Rights: Memory Detection Technologies and American Criminal Justice*, 8 AM. J. BIOETHICS 34, 36 (2008)); *see also* Schauer, *supra* note 331, at 1210 n.103 (citing numerous studies which suggest that juries are not as ill-equipped at evaluating scientific evidence as is commonly assumed).

364. Feigenson, *supra* note 89, at 44–48; Goodenough & Tucker, *supra* note 57, at 72 ("[A] potential for prejudice does not make neuroscience evidence inadmissible per se."); *see also* Schauer, *supra* note 331, at 1210 ("This reliance on juror incompetence to justify excluding neuroscience evidence seems misplaced . . . or, at the very least, premature."); Sinnott-Armstrong et al., *supra* note 301, at 370 (noting that, if used properly, brain scans might actually inform the jury and lead to more accurate conclusions instead of misleading the jury).

365. Feigenson, *supra* note 89, at 44–48.

366. *Id.* at 47–48; *see* Goodenough & Tucker, *supra* note 57, at 72 ("[J]urors' biases and misunderstandings are better held in check by more information rather than less."); *see also* Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 596 (1993) (stating that "[v]igorous cross-examination" and "presentation of contrary evidence" are the "traditional and appropriate means" to challenge scientific evidence).

would not only encourage juries to view the testimony critically, but would also allow legal judgments to "be rendered consistently with the best available scientific knowledge."[367] Scholars also counter critics' concern about the "Christmas tree effect"[368] by pointing out that admitting functional neuroimaging evidence would not prevent fact-finders from reaching a guilty verdict if they feel it is deserved,[369] a result corroborated by numerous cases.[370]

III. BRINGING FUNCTIONAL NEUROIMAGING INTO THE COURTROOM: NECESSARY AND USEFUL

Brain imaging technologies have progressed rapidly over the past thirty years.[371] One can only assume that the technology will continue to progress in the future, likely at a faster rate than before.[372] When it comes to bringing functional neuroimaging into the courtroom, scholars and judges alike have resisted doing so under *Daubert* and the federal admissibility standards.[373] At the same time, forensic individualization evidence is continually admitted at trial despite significant and egregious scientific failings.[374] Only a few courts subject the evidence to proper *Daubert* hearings, and even fewer still conduct evidentiary analyses.[375] This has resulted in an evidentiary double standard in federal criminal courts in which the forensic individualization evidence gets a "free pass" around *Daubert* while functional neuroimaging evidence cannot even leave the starting gate. This double standard should not be allowed to continue.

Part III argues that federal judges should carefully consider admitting functional neuroimaging evidence when it is offered in criminal trials,

367. Feigenson, *supra* note 89, at 48.

368. *See supra* note 160 and accompanying text (describing what some refer to as the "Christmas tree effect").

369. Feigenson, *supra note* 89 at 44–48; *see* Perlin, *supra* note 237, at 890; *see also* Ayd & Troeger, *supra* note 184, at 38 ("Jurors should participate in legal decision making, even when scientific or technical issues are involved."); Friedman, *supra* note 184, at 1061–64 (arguing that jurors would not be unfairly prejudiced if presented with such evidence, and that they can still effectively serve as finders of fact).

370. *See, e.g.*, United States v. Hammer, 404 F. Supp. 2d 676, 792–93 (M.D. Pa. 2005) (admitting neuroevidence at habeas corpus hearing but ultimately finding it unpersuasive as to defendant's competency), *appeal dismissed*, 564 F.3d 628 (3d Cir. 2009); State v. Anderson, 79 S.W.3d 420, 429 (Mo. 2002) (despite neurologist's testimony of defendant's brain damage, jury still found defendant guilty and sentenced him to death), *aff'd in part, rev'd in part on other grounds*, 196 S.W.3d 28 (Mo. 2006); Anemona Hartocollis, *Jury Finds Writer Guilty of Sex Attack, Rejecting Psychiatric Defense*, N.Y. TIMES, May 24, 2007, at B3; *see also* United States v. Sandoval-Mendoza, 472 F.3d 645, 656 (9th Cir. 2006) (reversing the lower court's decision to exclude evidence while noting that the jury is capable of reaching a conclusion and should have been presented with the evidence).

371. *See supra* notes 27–32 and accompanying text.

372. In fact, researchers recently developed technology that allows for significantly faster fMRI scans. *See New Technologies Allow for Faster Brain FMRIs*, MEDGADGET.COM (Jan. 12, 2011), http://www.medgadget.com/archives/2011/01/new_technologies_allow_for_faster_brain_fmris.html.

373. *See supra* Part II.A.

374. *See supra* Part I.D.4.

375. *See supra* Part I.D.4.

especially in light of the suspect quality of forensic evidence currently streaming into the courtroom. Admissibility should not be given carte blanche, however. Proper evidence standards must be maintained. Functional neuroimaging evidence can be potentially confusing and courts do have the right to control such evidence, but it should not be excluded per se. Fully utilizing the adversarial process of our court system would help the judge and the jury alike understand the nature, assumptions, and consequences of functional neuroimaging evidence.

A. Balancing the Evidence Presented to the Jury

The NRC's report thoroughly documented the dearth of significant or verifiable science[376] underlying the aptly named "non-science forensic sciences" known as forensic individualization.[377] Yet, as discussed above, there have been few attempts to improve these practices.[378] Forensic individualization sciences are still frequently admitted in federal courtrooms, often without undergoing a *Daubert* analysis; for those that do conduct a *Daubert* inquiry, the analysis is certainly not a rigorous one.[379] The lax admissibility threshold imposed on prosecutors[380] has led to many wrongful convictions, some of which have been overturned.[381] It remains unclear, however, just how many convictions premised on faulty or fraudulent forensic evidence are never revisited due to a lack of DNA or other exculpatory evidence.[382]

These deplorable consequences of evidence standards gone awry can be partially mitigated by leveling the evidentiary playing field. Functional neuroimaging evidence could provide defendants with the opportunity to present a fuller defense to the jury. Often unable to testify about their own mental state, defendants could offer functional neuroimaging evidence as the only source for such evidence and their only hope for presenting it before a judge or jury.[383]

It seems unlikely that judges will ban forensic individualization evidence in the near future, especially because most judges readily and even blindly admit it without first examining it under *Daubert*.[384] The NRC report clearly lays out the dangers and wholly inadequate science behind the widely admitted forensic individualization sciences.[385] Hopefully, future litigation will directly address the report to help turn the tide of this evidentiary debacle, but any change surely will be slow. The case law demonstrates the judicial system's long-running allegiance to the forensic

376. *See supra* Part I.D.3.
377. *See supra* note 214 and accompanying text.
378. *See supra* notes 217–18 and accompanying text.
379. *See supra* Part I.D.4.
380. *See supra* note 223 and accompanying text; *supra* Part I.D.2.
381. *See supra* notes 226–32 and accompanying text (discussing wrongful convictions based on faulty forensic evidence later overturned by DNA exonerations).
382. *See supra* note 200.
383. *See supra* Part II.B.3; *supra* notes 352–55 and accompanying text.
384. *See supra* Part I.D.4; *supra* note 251 and accompanying text.
385. *See supra* Part I.D.3.

sciences, however misplaced that allegiance may be.[386] As one scholar mused, "We have been marinated in a culture of faith in the validity of the non-science forensic sciences."[387] With this in mind, Judge Gertner's lament reverberates with renewed urgency: "[W]e should require more" from our criminal justice system.[388] The NRC's recommendation for federal oversight and regulation[389] is not only appropriate; it is necessary. If heeded, it will usher in a marked improvement in the reliability and validity of forensics.

Contrast forensic evidence's free ride into federal courts, bypassing *Daubert*, with one scholar's call for a moratorium on admitting all neuroscience into evidence until a regulatory agency can verify its reliability according to federal standards.[390] Such a moratorium is an unnecessarily drastic measure, especially considering the scientific validity underlying functional neuroimaging methodologies.[391] Absent a similar ban on forensic individualization evidence, courts should be even more willing to admit functional neuroimaging evidence. Judges should at least be no more hesitant to admit functional neuroimaging than they are to admit forensic individualization evidence. Doing so would add needed balance to the currently ravaged vista of criminal evidence.

This imbalance is compounded by the pro-prosecution bias in evidentiary hearings.[392] A defendant has little chance of presenting a useful defense at trial if judges employ an almost knee-jerk response in rejecting their challenges to forensic evidence while mostly granting prosecutors' motions to exclude defendants' forensic evidence.[393] Providing a jury with functional neuroimaging evidence would help the jury develop a more complete understanding of the defendant.[394] For example, if the prosecution presents the jury with particularly incriminating, yet scientifically questionable, forensic evidence, it would be a disservice to justice to silence the defendant by excluding functional neuroimaging evidence. Forensic evidence can be used to place the defendant at the scene of the crime[395] and would essentially be the "smoking gun" to a jury—unless the defendant can try to counterbalance it with evidence that he may not have been able to form the requisite intent, was unaware of his actions, or should not be held as accountable as someone with no evidence of brain dysfunction. Perhaps the jury will find that the defendant's aggression was partially caused by brain dysfunction, and perhaps not. Whether the jury

386. *See supra* notes 249–65 and accompanying text (discussing federal courts' resistance to challenging the pedigree of forensic evidence despite recognizing the evidence's weaknesses).

387. Saks, *supra* note 206, at 336.

388. *See supra* notes 262–65 and accompanying text.

389. *See supra* notes 244–48 and accompanying text.

390. Greely & Illes, *supra* note 90, at 395–404.

391. *See supra* notes 338–44 and accompanying text.

392. *See supra* notes 191; 234–38 and accompanying text.

393. *See supra* notes 234–37 and accompanying text.

394. *See supra* notes 357–59 and accompanying text.

395. *See supra* notes 228–32 and accompanying text.

will find such evidence persuasive is a separate issue, and beyond the scope of this Note. The important point is that the evidence should be presented to the jury. After all, a verdict can wholly depend on whether any single piece of evidence places some amount of doubt in the jury's mind.[396]

The critiques raised against functional neuroimaging evidence[397] apply with just as much force—perhaps even more—to forensic individualization evidence. Critics argue that no regulations govern the use and interpretation of functional neuroimaging.[398] Yet forensic individualization also lacks standardization and regulations governing its use.[399] Opponents claim that functional neuroimaging is unreliable because it necessarily involves interpretations based on correlations rather than direct causation, relying on comparisons drawn from a generalized "normal" population.[400] Yet forensic individualization rests entirely on probability and draws extensively from the expert's subjective analysis.[401] Critics also reject functional brain scans for their inability to represent a defendant's past mental state accurately, given the dynamic and prohibitively complex interconnectedness of the brain.[402] However, forensic individualization depends heavily on highly similar methods of analysis. Forensic experts may analyze physical, unique traits observed on physical objects,[403] but experts usually have access only to samples, which are often incomplete and sometimes even temporally dynamic.[404] For example, bite marks on the skin change over time.[405] They can be easily distorted by the elasticity of the skin, distribution of force of the bite, variations in swelling and healing, time, fitness of the victim, and other factors.[406] When forensic experts analyze these marks, they necessarily draw inferential connections similar to those drawn by functional brain imaging experts, analyzing the measured and collected results and formulating conclusions drawn from their subjective experiences, observations, and training.[407]

The analyses of these two types of forensic evidence may involve similar methods, but the validity of the scientific methodology employed for functional neuroimaging and forensic individualization differs greatly. The NRC report,[408] numerous scholars and commentators,[409] and recently even

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396. *See supra* note 369–70 and accompanying text.

397. *See supra* Part II.A.

398. *See supra* Part II.A.1.

399. *See supra* notes 244–48 and accompanying text.

400. *See supra* notes 62–65, 291–97 and accompanying text.

401. *See supra* notes 203–07 and accompanying text.

402. *See supra* Part II.A.2.

403. This includes blood, bite marks, etchings on tool marks, fingerprints, and the like. *See supra* Part I.D.1.

404. *See* Moriarty & Saks, *supra* note 17, at 26.

405. *See* NRC REPORT, *supra* note 166, at 174. Similar problems of temporal dynamism occur with toolmark analysis. *See* Moriarty & Saks, *supra* note 17, at 26.

406. NRC REPORT, *supra* note 166, at 174.

407. Moriarty & Saks, *supra* note 17, at 26 ("[I]t is necessary [for forensic analysts] to use methods of analysis that are capable of making useful estimates about *samples* or a temporally changing target."). The same holds true for inferential leaps that experts make when they only have partial fingerprints. *Id.*

408. *See supra* Part I.D.3.

some courts[410] have documented the almost complete dearth of scientific support for forensic individualization. *Daubert* requires that scientific evidence be scientifically reliable to be admissible, but forensic individualization evidence is nothing if not unscientific. Functional neuroimaging, on the other hand, is based on scientifically sound methodologies.[411]

B. *Normative, Not Scientific, Issues*

Not only will functional neuroimaging restore balance to the palette of evidence admitted in criminal trials, but it would also properly restore fact-finding duties to the jury.[412] Judges who exclude the evidence without conducting proper *Daubert* analyses evaluate the merits and conclusions drawn from the evidence as opposed to the underlying methodologies. *Daubert* specifically prohibits judges from doing just that.[413] If the evidence were admitted, juries would be free to use it as they see fit.[414] Experts would testify about the implications of the brain scans and how the scans might help the jury reach an ultimate conclusion about a defendant's mental state;[415] the expert's testimony, however, would by no means be dispositive.[416] The jury would decide what to do with the evidence and how much weight to grant it.[417] In other words, jurors would decide how to weave the functional neuroimaging evidence into the fabric of the rest of the evidence presented to them—that is, if the jury decides to consider the evidence at all.

When faced with functional neuroimaging evidence, a judge should not allow scientific questions to cloud his gatekeeping duties.[418] Those questions have already been answered with ample research supporting the scientific methodologies employed.[419] Even if a court were to reject the supporting scientific research, the evidence most likely would pass *Daubert*'s requirements for scientific validity. Thus, judges should view the evidence from a normative or judicial standard, rather than a scientific one, and let the jury evaluate it. Jurors are the arbiters of truth, the fact-finders who must determine normative questions of how to weigh a piece of evidence, and ultimately, of culpability.[420] Treating the evidence

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409. *See supra* notes 217–18 and accompanying text.

410. *See supra* notes 262–65, 274 and accompanying text.

411. *See* Brown & Murphy, *supra* note 54, at 1177 (noting that the methodology of functional neuroimaging is scientifically sound and would survive both *Daubert* and *Frye* analyses); *supra* Parts I.B.1, II.B.2.

412. *See supra* notes 174–75 and accompanying text.

413. *See supra* notes 125, 170–73 and accompanying text.

414. *See supra* note 172 and accompanying text.

415. *See supra* Parts II.B.2, II.B.4, note 349 and accompanying text.

416. *See supra* notes 161–65 and accompanying text.

417. *See supra* Part II.B.4; *see also supra* notes 270–73 and accompanying text.

418. Once such question is whether the science of functional neuroimaging is sufficiently reliable to pass *Daubert*.

419. *See supra* note 334 and accompanying text.

420. *See supra* Part I.C.3.

normatively mitigates concern for misleading the jury because the jury could simply discard the evidence as unpersuasive.[421]

Furthermore, litigating parties should use cross-examination and the adversarial system to focus and clarify the issue for the jury.[422] As Professor Feigenson advocates, juries should be presented with more, not less, neuroimaging evidence.[423] The Supreme Court has endorsed this jurisprudential philosophy, both in *Daubert* and elsewhere,[424] declaring that the adversarial nature of our legal system is keenly capable of discovering the truth.[425] Thus, courts should consider admitting neuroimaging evidence not only because it likely passes *Daubert*'s "science" requirements,[426] but also because at trial, both sides can properly present and explain the evidence so it does not mislead or prejudice the jury.

In *Sandoval-Mendoza*,[427] the Ninth Circuit placed a premium on admitting functional neuroimaging evidence so that the jury could reach a reasonable conclusion about the defendant's mental state.[428] Viewing the evidence normatively, the court recognized that only the jury could evaluate the evidence; excluding it therefore constituted reversible error.[429] That the court reversed the evidentiary decision is significant because the standard of review for evidentiary hearings is abuse of discretion.[430] The reversal was thus a resounding vote of confidence in favor of admitting the evidence and its utility in assisting the jury.[431] As highlighted by *Sandoval-Mendoza*, the jury should not be underestimated, and neither should the jury nor the defendant be denied the possible benefits of functional neuroimaging evidence per se.

This Note does not advocate for judges to freely admit functional neuroimaging evidence. But, since the evidence most likely survives a *Daubert* analysis,[432] and assuming that the evidence is sufficiently probative,[433] federal judges should strongly consider admitting it more frequently in criminal trials. Judges should also strive to ensure that admitted evidence continues to be reliable, and if necessary, to regulate the extent of the testimony through procedural methods such as carefully crafted jury instructions[434] or directed verdicts.[435] Furthermore, agencies

421. *See supra* note 370 and accompanying text (citing cases where juries disregarded functional neuroimaging evidence); *see also supra* notes 362–63 and accompanying text.

422. *See supra* notes 366–70 and accompanying text.

423. *See supra* notes 365–67 and accompanying text.

424. *See supra* notes 132–35 and accompanying text.

425. *See* White v. Illinois, 502 U.S. 346, 356 (1992) (quoting California v. Green, 399 U.S. 149, 158 (1970)).

426. *See supra* notes 339–44 and accompanying text.

427. 472 F.3d 645 (9th Cir. 2006); *see supra* notes 352–55 and accompanying text.

428. *See supra* note 354 and accompanying text.

429. *Sandoval-Mendoza*, 472 F.3d. at 656.

430. *See supra* notes 137, 151 and accompanying text.

431. *See supra* note 184 and accompanying text.

432. *See supra* Part II.B.2.

433. *See supra* Part II.B.4–5.

434. *See supra* note 21 and accompanying text.

435. *See supra* note 135.

such as the Institute of Medicine should establish regulatory boards to govern the research, development, and application of functional neuroimaging evidence and to supervise the imaging methods.[436] Doing so would ensure continued reliability while serving the interests of justice by allowing litigating parties to introduce relevant and probative evidence.

CONCLUSION

Courts considering functional neuroimaging evidence have applied an evidentiary double standard. Charged with gatekeeping duties under *Daubert*, they are supposed to prevent empirically unreliable evidence from entering the courtroom. But in federal criminal trials, judges often turn a blind eye towards unscientific forensic individualization evidence, refusing to analyze it under *Daubert*. Instead, it is often inappropriately admitted into evidence because of its pedigree. Functional neuroimaging evidence, however, has been met with a more skeptical eye and subjected to significantly stricter *Daubert* standards than its forensic counterparts. This has resulted in an unfair, and pro-prosecution, evidentiary bias.

Meanwhile, scholars and commentators continue to debate the merits and detriments of functional neuroimaging evidence. But most critics of functional neuroimaging evidence do not consider the disparity in evidentiary standards that exists in federal criminal trials. Accordingly, judges should carefully and fairly examine functional neuroimaging evidence when offered in federal criminal trials. It should not be excluded out of hand. As is frequently the case in criminal trials where this type of evidence can make a difference, the stakes will be high and the needs will be immediate. Jurors should be presented with the evidence—all the evidence possible—so that they can determine how best to weave together the various pieces to create a complete tapestry of evidence.

John Hinckley, Jr. was found not guilty by reason of insanity after his lawyers showed the jury pictures of his atrophied brain. Was the jury correct in finding him not guilty? Was the verdict largely due to the pictures of his brain that were displayed to the jury? Those questions remain unanswered. But now, thirty years later, when both sides have a better understanding of neuroimaging evidence and can more fully prepare for its use in court, neither juries nor defendants should be denied the benefits provided by functional neuroimaging evidence.

436. *See supra* note 22 and accompanying text.