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Comments: Functional Magnetic Resonance Imaging and the Law Today: The Brain Is Reliable as a Mitigating Factor, but Unreliable as an Aggravating Factor or as a Method of Lie Detection

Kristina E. Donahue
University of Baltimore School of Law

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FUNCTIONAL MAGNETIC RESONANCE IMAGING AND THE
LAW TODAY: THE BRAIN IS RELIABLE AS A MITIGATING
FACTOR, BUT UNRELIABLE AS AN AGGRAVATING
FACTOR OR AS A METHOD OF LIE DETECTION.

I. INTRODUCTION

Charles Whitman was an exemplary individual; he was a husband and a son, an Eagle Scout, a scholarship student at the University of Texas, and he had just joined the United States Marine Corps.¹ Yet, on August 1, 1966, he brutally stabbed and murdered his wife and mother.² Later that day, he ascended the University of Texas Tower and gunned down forty-five people, committing what was then the largest simultaneous mass murder in American history.³ In order to end the shooting spree, Austin police were forced to shoot and kill Whitman.⁴ In total, Charles Whitman savagely killed sixteen people and wounded thirty-one others.⁵ After this horrific event, investigators discovered a note written by Whitman in which he expressed confusion as to why he felt compelled to commit the murders and detailed the severe headaches and disturbing thoughts he had recently developed.⁶ An autopsy revealed a brain tumor in the hypothalamus region of Whitman's brain, which was compressing and over-stimulating the amygdala.⁷ Functional magnetic resonance imaging (fMRI) has since revealed that over-stimulation of the amygdala results in uncontrollable violent behavior and the inability of an individual to understand and appreciate criminal behavior.⁸ FMRI technology can help shed light on why individuals like Charles Whitman do what they do, and this raises the question of what role such evidence should play in the judicial system.

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1. Shelley Batts, *Brain Lesions and Their Implications in Criminal Responsibility*, 27 BEHAV. SCI. & L. 261, 268 (2009).
 2. GARY M. LAVERGNE, A SNIPER IN THE TOWER: THE CHARLES WHITMAN MURDERS 103, 105, 107-08 (1997).
 3. *Id.* at back cover.
 4. *See* Batts, *supra* note 1, at 268.
 5. *Id.*
 6. *Id.*
 7. *Id.*
 8. *See id.* at 268-69.

fMRI is a scientific technique used to image the brain's activity while an individual is engaging in a specific task or sensory process.⁹ fMRI technology allows researchers to monitor the functioning of the brain by comparing the brain's consumption of oxygen in specific areas during movement, thought, sensation, and emotion.¹⁰ Scientific research thus far has used fMRI for two main purposes: lie detection and the identification of functional or structural impairments within the brain.¹¹

These scientific advances have raised many questions about the potential role of fMRI evidence in the legal system.¹² This comment will argue that fMRI as a method of distinguishing truth from falsehood is not yet reliable enough for use as substantive evidence in court, as the results are not consistent due to the variability and complexities in the brain patterns associated with different forms of lying.¹³ However, fMRI evidence of increased violent and aggressive impulses, which result from impairment of the amygdala and prefrontal cortex regions of the brain, meets the "preponderance of the evidence" standard required for the admissibility of mitigation evidence during both federal and Maryland state sentencing proceedings, and, therefore, fMRI evidence should be considered by the court and the jury as a mitigating factor during sentencing.¹⁴ But fMRI evidence does not meet the "beyond a reasonable doubt" standard that is required for admission as an aggravating factor at this time.¹⁵

More importantly, this technology raises the larger concern as to what role fMRI should play in the law in the future when the technology evolves to the point where fMRI evidence can meet the

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9. See John C. Gore, *Principles and Practice of Functional MRI of the Human Brain*, 112 J. CLINICAL INVESTIGATION 4, 4 (2003).
 10. See Henry T. Greely, *Neuroethics and ELSI: Similarities and Differences*, 7 MINN. J. L. SCI. & TECH. 599, 612-13 (2006).
 11. See Paul S. Appelbaum, *The New Lie Detectors: Neuroscience, Deception, and the Courts*, 58 PSYCHIATRIC SERVICES 460, 461 (2007); John Matthew Fabian, *Neuropsychological and Neurological Correlates in Violent and Homicidal Offenders: A Legal and Neuroscience Perspective*, 15 AGGRESSION & VIOLENT BEHAV. 209, 211 (2010).
 12. See Appelbaum, *supra* note 11, at 461.
 13. See *id.*; G. Ganis et al., *Neural Correlates of Different Types of Deception: An fMRI Investigation*, 13 CEREBRAL CORTEX 830, 835 (2003); *infra* notes 53-69 and accompanying text.
 14. See Fabian, *supra* note 11, at 217-19; *infra* notes 99-108 and accompanying text. See generally *United States v. O'Brien*, 130 S. Ct. 2169, 2174 (2010) (holding that the standard for proving mitigating or aggravating factors at sentencing is a preponderance of the evidence standard).
 15. See *infra* notes 121-125.

beyond a reasonable doubt standard required for admission as an aggravating factor and, perhaps even more troubling, to the point where such fMRI evidence is reliable enough to meet the *Daubert* and *Frye-Reed* tests for admissibility as substantive evidence for the determination of guilt.¹⁶

II. FUNCTIONAL MAGNETIC RESONANCE IMAGING

A. *The Principles*

The brain is a vastly complex organ; however, scientific research has revealed that specific areas of the brain are associated with distinct cognitive and behavioral functions.¹⁷ For example, the motor and pre-motor cortices regulate movement of body parts; the Broca's and Wernicke's areas regulate understanding and production of speech; the prefrontal cortex translates sensory and non-sensory input into information used to make decisions and choices; and the amygdala regulates perception of and responses to emotional stimuli.¹⁸ Each function is associated with specific patterns of neuronal firing and activation, such that an increase in neuronal activity in a given area of the brain represents an increase in the cognitive or behavioral function of that region.¹⁹

Neurons obtain the energy needed for firing and activation from the oxygenated blood that is transported to the brain in response to a stimulus or event.²⁰ Oxygenated blood behaves differently than deoxygenated blood in magnetic fields, and this enables fMRI to measure changes in neuronal activity within different areas of the brain.²¹ fMRI detects the blood oxygen level dependent (BOLD) response, based on the influx of oxygenated blood to a specific area

16. See Appelbaum, *supra* note 11, at 461–62; *infra* Part IV.

17. Batts, *supra* note 1, at 265.

18. See *id.* at 265–69.

19. 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, 1138 (2010).

20. See *id.*

21. See Gore, *supra* note 9, at 4. Deoxygenated hemoglobin is paramagnetic, similar to the contrast agents used in conventional MRI scans. *Id.* This results in a lack of uniformity that causes the magnetic field and BOLD response signal to deteriorate faster. See *id.* On the other hand, oxygenated hemoglobin is similar in its magnetic properties to tissue and so a stronger, more uniform BOLD response signal results. See *id.*

of the brain.²² A positive BOLD response will result where there is a net increase in the ratio of oxygenated to deoxygenated blood.²³ Thus, a positive BOLD response indicates increased activity in that particular area of the brain.²⁴ Conversely, a negative BOLD response results where there is a net decrease in the ratio of oxygenated to deoxygenated blood, and indicates a decrease in activity in that specific area of the brain.²⁵

B. *The Procedure*

When undergoing an fMRI scan, the subject must lie down on his or her back on a narrow bed.²⁶ The bed and the subject are then inserted into the center of a cylindrical tube with a magnetic core.²⁷ The subject is instructed to lie as still as possible, but, if the subject is unable to do so, his or her head may be placed in a headrest to ensure there is no movement of the brain.²⁸ Once the subject is in place, strong magnetic coils measure electrical currents in the form of BOLD responses within the subject's brain.²⁹ Depending on the research question, various audio or visual stimuli may be administered during the scan, or the subject may be asked to perform tasks or select buttons corresponding to different answers on a small remote control device, while continuing to remain as still as possible.³⁰ The technology of the fMRI machine allows for cross-sectional images of the subject's brain to be taken every 50 to 100 milliseconds throughout the duration of the scan.³¹ This is advantageous because it allows for multiple recordings of the brain's

22. *See id.* An increase in the level and intensity of brain activity occurring in a particular region will result in an increased flow of oxygenated blood to the area. *Id.*

23. *See id.*; Brown & Murphy, *supra* note 19, at 1139.

24. *See Gore, supra* note 9, at 4–5.

25. *See Brown & Murphy, supra* note 19, at 1139.

26. United States v. Semrau, No. 07-10074M1/P, 2010 WL 6845092, at *3 (W.D. Tenn. June 1, 2010).

27. *See id.*

28. Brown & Murphy, *supra* note 19, at 1139; *see also Semrau*, 2010 WL 6845092, at *3.

29. *See Brown & Murphy, supra* note 19, at 1139. There are two main types of fMRI studies that can be performed: block designs, where different stimuli are presented in alternating periods of several seconds each and then compared to one another for an average result, and transient stimuli, which are more event-related. *See Gore, supra* note 9, at 5–6.

30. Brown & Murphy, *supra* note 19, at 1139.

31. Gore, *supra* note 9, at 5. The cross-sections are recorded so quickly that images within the same brain state may differ from one another due to extraneous “noise” from voltage in the magnetic coils or components used to record the fMRI signals. *Id.* However, the images do not suffer blurring from physiological motion, which can be a concern with other forms of scans. *Id.*

response to each repeated stimuli.³² The data sets of BOLD response recordings are then compared and averaged in order to increase the reliability of the measured BOLD response.³³ A computer algorithm quantitatively analyzes the data in order to complete this comparison and averaging of the data sets.³⁴ The measured BOLD responses are then compared to the subject's control BOLD responses in order to identify changes in the intensity of the signals and, thus, the corresponding changes in activity in specific areas of the subject's brain.³⁵

C. *The Concerns*

It is important to note, however, that there are limitations associated with fMRI technology.³⁶ The BOLD responses can be hard to measure because they are very small, typically around a 1% change in neural activity.³⁷ Furthermore, variations in other blood components, such as the subject's levels of glucose or caffeine, are also likely to affect the BOLD response, yet the effects of such variations are not well understood.³⁸ Finally, an impaired blood supply to the brain may also affect the magnitude of the BOLD response.³⁹ Despite these limitations, fMRI techniques can measure subtle changes in the state of the brain in order to map brain functions.⁴⁰

32. *See id.*

33. *See id.*

34. *See id.*

35. *United States v. Semrau*, No. 07-10074M1/P, 2010 WL 6845092, at *3 (W.D. Tenn. June 1, 2010). Each subject undergoes the fMRI procedure two times: the first time obtains baseline, control responses; the second time measures the subject's responses to the various stimuli.

36. *See Gore*, *supra* note 9, at 8.

37. *See id.* at 4–5, 8.

38. *Id.* at 9.

39. *See id.*

40. *Id.*

III. FUNCTIONAL MAGNETIC RESONANCE IMAGING AND THE LAW

A. *Admissibility of Functional Magnetic Resonance Imaging as Substantive Evidence*

1. Functional Magnetic Resonance Imaging as Evidence of Deception

Recent scientific studies have used fMRI technology as a lie detection tool to distinguish truthful from untruthful responses.⁴¹ This application is based on research suggesting that different patterns of activity within the brain result when someone is telling the truth versus when someone is telling a lie.⁴² In general, lying results in increased brain activity, because the brain is working to suppress an otherwise truthful response in favor of a fabrication.⁴³

One such fMRI study found that “distinct neural networks support different types of deception.”⁴⁴ The study focused on two specific types of lies: spontaneous-isolated lies and memorized-scenario lies.⁴⁵ To tell a spontaneous-isolated lie, an individual must keep the truth in mind while generating alternative lies in order to select among them.⁴⁶ This process involves both semantic and episodic memory, which are associated with the ventrolateral prefrontal cortex and the anterior prefrontal cortex respectively.⁴⁷ On the other hand, memorized-scenario lies require the individual to recall only a specific lie, and thus only episodic memory is involved.⁴⁸ The results of the study confirmed that not only is there an increase in brain activity when an individual is lying, but that there are different patterns of brain activity for different types of lies.⁴⁹

While this study is consistent with two of the three previous fMRI research studies related to lie detection, it is inconsistent with the third study, which showed activation in a different area of the brain

41. Appelbaum, *supra* note 11, at 461.

42. *Id.*

43. *Id.*

44. Ganis et al., *supra* note 13, at 830.

45. *Id.* at 831.

46. *Id.*

47. *Id.* Semantic memory refers to an individual thinking of all plausible responses to the question, whereas episodic memory refers to an individual thinking of a specific event. *Id.* Spontaneous-isolated lies may also involve activation in the ventral stream regions “if these retrieval systems are also accompanied by visual imagery.” *Id.*

48. *Id.* at 831.

49. *Id.* at 833. Block design fMRI testing was used in this study, and subjects were required to provide either binary button or single word responses. *Id.* at 832.

for spontaneous-isolated lies.⁵⁰ This is concerning because the majority of fMRI research thus far has been based on group analysis, and if data is not consistent with regard to which brain areas show increased activity during forms of deception, there can be no individualized, real-world applications of the fMRI technique.⁵¹ Furthermore, partial truths and truths after contemplation of lying have yet to be studied, and these forms of lies are likely common in human behavior.⁵²

2. Analysis for Admissibility of Functional Magnetic Resonance Imaging as Evidence of Deception Under *Daubert*

In 1993, the United States Supreme Court held that the Federal Rules of Evidence superseded *Frye*'s "general acceptance" test for admissibility of scientific evidence, rejecting the *Frye* test in favor of the *Daubert* test.⁵³ The touchstone for the *Daubert* test is the reliability of the scientific evidence.⁵⁴ The Court held that the standard for determining reliability is a multi-factor analysis considering whether the technique can be or has been tested, whether the technique has been subjected to peer review and publication, the known or potential rate of error of the technique, and whether the technique has been generally accepted by the scientific community.⁵⁵ The *Daubert* test is flexible and the factors are tailored to the specific facts of the case, as opposed to being viewed as a definitive checklist.⁵⁶

The first two factors of the *Daubert* test have been satisfied by research in the scientific community utilizing fMRI as a tool to detect deception: fMRI has been and can continue to be subjected to testing, and fMRI has been and can continue to be subjected to peer review and publication.⁵⁷ Nevertheless, fMRI is unreliable as a method of

50. *Id.* at 835. Researchers attribute the difference in the brain activation for the spontaneous-isolated lies to the use of different block stimuli. *See id.*

51. *See* Appelbaum, *supra* note 11, at 461. "Even if group norms of liars and truth-tellers differ in a particular study, unless specific brain regions are consistently associated with deception it will be difficult to apply these findings to the assessment of truthfulness among particular individuals." *Id.*

52. *See id.*

53. *Daubert v. Merrell Dow Pharm., Inc.*, 509 U.S. 579, 585, 587–90 (1993).

54. *Id.* at 589.

55. *Id.* at 593–94.

56. *Id.* at 593.

57. *United States v. Semrau*, No. 07-10074M1/P, 2010 WL 6845092, at *10 (W.D. Tenn. June 1, 2010); *see, e.g.*, Batts, *supra* note 1; Appelbaum, *supra* note 11; Fabian, *supra* note 11; Ganis et al., *supra* note 13.

detecting deception.⁵⁸ The error rate of fMRI studies for this purpose remains unknown, and there has been no real-life or real-world application of the technique.⁵⁹ Additionally, researchers acknowledge that the various studies utilizing fMRI to detect lies have produced inconsistent results, as different studies show different areas of increased activation within the brain as a result of deception.⁶⁰ Accordingly, the scientific community has yet to generally accept fMRI-based lie detection as a valid tool to separate truth from falsehood.⁶¹ Therefore, admissibility of fMRI as a lie-detection method fails the *Daubert* test of admissibility.⁶²

3. Analysis for Admissibility of Functional Magnetic Resonance Imaging as Evidence of Deception Under *Frye-Reed*

Prior to the Supreme Court's decision in *Daubert*, in *Frye v. United States*, the Court of Appeals for the District of Columbia held that scientific techniques or theories "must be sufficiently established to have gained general acceptance in the particular field in which [they] belong" in order to be admissible in evidence.⁶³ The Maryland Court of Appeals adopted this test in *Reed v. State*,⁶⁴ and Maryland continues to adhere to the *Frye* general acceptance standard.⁶⁵ Thus, under Maryland law, if a technique is generally regarded as experimental within the scientific community, the technique is not reliable, and cannot be admitted into evidence.⁶⁶

The technique of fMRI lie detection fails the general acceptance test, because disagreement exists among researchers as to the specific brain areas of increased activity when a person is being deceptive.⁶⁷ Furthermore, some neuroscientists doubt the real-world applicability of fMRI lie detection because in all of the studies thus far, subjects have been instructed to lie, and it is quite clear that this would not be

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

59. *Id.* at *11, *13.

60. *See Appelbaum*, *supra* note 11, at 462; Ganis et al., *supra* note 13, at 835.

61. *Semrau*, 2010 WL 6845092, at *13.

62. *See supra* notes 58–61 and accompanying text.

63. *Frye v. United States*, 293 F. 1013, 1014 (D.C. Cir. 1923).

64. *Reed v. State*, 283 Md. 374, 389, 391 A.2d 364, 372 (1978).

65. *Clemons v. State*, 392 Md. 339, 349 n.7, 896 A.2d 1059, 1065 n.7 (2006) (holding that Maryland has not yet accepted the *Daubert* test).

66. *Reed*, 283 Md. at 381, 391 A.2d at 368.

67. *Appelbaum*, *supra* note 11, at 461; *see also Reed*, 283 Md. at 388, 391 A.2d at 371 (holding that if a scientific technique has achieved general acceptance in the scientific community, there will be little disagreement in the field as to the reliability of the technique's results).

the case in the real world.⁶⁸ Without consistency and general acceptance of fMRI lie detection studies, the results of such studies should not be admitted as substantive evidence in any court proceeding.⁶⁹

B. Admissibility of Functional Magnetic Resonance Imaging During Sentencing

1. Functional Magnetic Resonance Imaging as Evidence of Increased Violence and Aggression Resulting from Damage to the Amygdala and Prefrontal Cortex Regions of the Brain

Neurological research has linked functional and structural impairments of the brain to increased violence and aggression.⁷⁰ The prefrontal cortex and the amygdala are critical performance centers in the brain's system that grasp, organize, and categorize stimuli in order to regulate emotion.⁷¹ The amygdala enhances perception and memory of emotional stimuli by mediating between the limbic system, which regulates emotions and behavior, and the structures involved in memory processing.⁷²

FMRI has confirmed that the medial amygdala exerts inhibitory influences, whereas the lateral amygdala exerts excitatory influences.⁷³ In essence, the amygdala can directly inhibit or excite anger, aggression, memory and language impairment, responses to emotional stimuli, the "fight or flight" response system, and behavior.⁷⁴ Furthermore, fMRI has confirmed that the prefrontal cortex directly regulates both an individual's ability to make choices and decisions related to the exertion of self-control, and the ability to perceive and act normally by processing input from sensory and non-sensory areas of the brain, including the amygdala.⁷⁵ The prefrontal cortex has also been linked to an individual's ability to understand

68. See Henry T. Greely & Judy Illes, *Neuroscience-Based Lie Detection: The Urgent Need for Regulation*, 33 AM. J.L. & MED. 377, 403–04 (2007) (distinguishing the artificial environment of the laboratory from the real world when discussing the real-world application of fMRI lie detection).

69. See *supra* note 51 and accompanying text.

70. Fabian, *supra* note 11, at 211; see also Batts, *supra* note 1, at 268 (discussing the effects of increased stimulation in the amygdala).

71. Theodore Y. Blumoff, *Foreword: The Brain Sciences and Criminal Law Norms*, 62 MERCER L. REV. 705, 737 (2011).

72. Batts, *supra* note 1, at 269.

73. *Id.*

74. See *id.*; Fabian, *supra* note 11, at 212–13.

75. See Batts, *supra* note 1, at 268–69.

and process information, reason, control impulses, use knowledge to regulate behavior, understand and respond to the actions of others, empathize, and manipulate stored information in order to make decisions.⁷⁶

The interplay between the amygdala and the prefrontal cortex directly impacts an individual's free will and decision making abilities.⁷⁷ The amygdala immediately interprets emotional stimulations and transmits them through the neural system to the prefrontal cortex, which processes the input, allowing time for thought, reason, and conscious awareness before action is taken.⁷⁸ Thus, it is only when these two neural circuits are operating properly, both independently and dependently, that an individual is afforded the ability to reflect, reason, and act with a conscious and willful purpose.⁷⁹

In order to understand how deficiencies and malformations in the amygdala and prefrontal cortex of the brain affect an individual's aggressive and violent behavior, one must understand that aggression ranges from predisposed predatory behavior to defensive behavior.⁸⁰ Individuals with a predisposition to violence and aggression act with purpose, and their rage is often channeled into a premeditated violent act that is used to achieve a certain objective.⁸¹ On the other hand, defensively violent and aggressive individuals respond to a stressful and threatening situation in an attempt to reduce the threat, and "the violence is immediate, impulsive, emotional and reactive rather than planned and premeditated."⁸² Reactive aggression is associated with the amygdala, while calculated aggression is associated with the prefrontal cortex.⁸³

76. Fabian, *supra* note 11, at 212.

77. *Id.* at 216.

78. *See id.* at 216–17; Batts, *supra* note 1, at 268–69. The amygdala is also involved in learning which behavior is the correct behavior to use in order to achieve a goal or a reward because the amygdala provides a reward signal after engaging in the reactive behavior. Fabian, *supra* note 11, at 211. If an individual's amygdala produces a reward signal after the individual engages in violent, aggressive behavior, the individual will be more likely to engage in that form of behavior in the future in order to achieve a goal or reward. *Id.* The prefrontal cortex plays an important role in regulating the reward signals of the amygdala in order to delay "immediate gratification in order to achieve a more rational or eventually more rewarding long-term goal." *See* Batts, *supra* note 1, at 268.

79. Fabian, *supra* note 11, at 217.

80. *See id.* at 210.

81. *See id.* at 210–11.

82. *Id.* at 211.

83. *See id.*

fMRI neuroimaging data shows that a damaged amygdala can lead to an inability to properly respond and adapt to fear and form stimulus-punishment associations.⁸⁴ More specifically, a damaged amygdala impairs an individual's ability to accurately perceive emotional stimuli and, when the amygdala is over-stimulated, results in increased feelings of fear and aggression.⁸⁵ Furthermore, fMRI has shown that when the prefrontal cortex is damaged, not all available information related to the decision-making process can be utilized and considered during decision making.⁸⁶ This can result in an individual acting without realizing or understanding that their behavior is wrong or criminal.⁸⁷ Correlative research studies have shown "that damage or dysfunction [within] the prefrontal cortex [results in] a significant predisposition to antisocial and violent behavior."⁸⁸ This is because individuals with damaged prefrontal cortices cannot properly inhibit the amygdala subcortical emotional center, and thus they are biologically vulnerable to impulsive violence and aggression because they cannot properly anticipate future consequences of their actions.⁸⁹

2. Mitigation and Sentencing

"It has been uniform and constant in the federal judicial tradition for the sentencing judge to consider every convicted person as an individual and every case as a unique study in the human failings that sometimes mitigate, sometimes magnify, the crime and the punishment to ensue."⁹⁰ In order for courts to properly sentence an individual for the crime committed, the courts must have all the information they can obtain concerning the defendant's life and characteristics.⁹¹

84. *See id.* at 213.

85. *See Batts, supra* note 1, at 268–69.

86. *Id.* at 268.

87. *Id.*

88. Fabian, *supra* note 11, at 211. Both reduction in prefrontal cortical size and decreased prefrontal cortical activity is associated with increased violence and aggression. *Id.* Evidence shows that the most significant form of aggression associated with prefrontal injuries or malformations is reactive, impulsive aggression as opposed to predatory, premeditated aggression. *See id.*

89. *Id.* at 211–12.

90. *Koon v. United States*, 518 U.S. 81, 113 (1996); *see also Williams v. New York*, 337 U.S. 241, 247 (1949) (holding that "the punishment should fit the offender and not merely the crime" (citing *People v. Johnson*, 169 N.E. 619, 621 (N.Y. 1930))).

91. *Pepper v. United States*, 131 S. Ct. 1229, 1240 (2011) (quoting *Williams*, 337 U.S. at 247).

Congress has codified this principle in Title 18, Section 3661 of the United States Code, which states, “*no limitation* shall be placed on the information concerning the background, character, and conduct of a person convicted of an offense which a court of the United States may receive and consider for the purpose of imposing an appropriate sentence.”⁹² Therefore, sentencing courts are largely unlimited in both the kind of information they may consider and the source of the information.⁹³

It is also well settled in Maryland state courts that during sentencing, the court may consider a broad range of evidence, including mitigating factors such as:

[T]he murder was committed while the capacity of the defendant to appreciate the criminality of the defendant’s conduct or to conform that conduct to the requirements of law was substantially *impaired due to emotional disturbance, mental disorder, or mental incapacity*; . . . [or] any other fact that the court or jury specifically sets forth in writing as a mitigating circumstance in the case.⁹⁴

The defendant has the burden of raising any mitigating factors to be considered during sentencing.⁹⁵ The standard of proof for such mitigating factors, in both federal and Maryland state court, is a preponderance of the evidence.⁹⁶ “To prove by a preponderance of the evidence means to prove that something is more likely . . . than not”⁹⁷ If the court or the jury finds that mitigating circumstances

92. 18 U.S.C. § 3661 (2006) (emphasis added).

93. *United States v. Tucker*, 404 U.S. 443, 446 (1972).

94. MD. CODE ANN., CRIM. LAW § 2-303(h)(2)(iv), (viii) (LexisNexis 2012) (emphasis added). The sentencing court may also consider mitigating factors such as:

[T]he victim was a participant . . . or consented to the act that caused the victim’s death; the defendant acted under substantial duress, domination, or provocation . . . ; the defendant was of a youthful age . . . ; the act of the defendant was not the sole proximate cause . . . ; and it is unlikely that the defendant will engage in further criminal activity that would be a continuing threat to society.

Id. § 2-303(h)(2).

95. *Colvin v. State*, 299 Md. 88, 126, 472 A.2d 953, 972 (1984).

96. *Stebbing v. State*, 299 Md. 331, 361, 473 A.2d 903, 918 (1984) (holding that it is the accused’s burden to prove, by a preponderance of the evidence, the existence of a mitigating circumstance); *see also* *United States v. Jeffers*, 570 F.3d 557, 570 (4th Cir. 2009) (holding that a sentencing court is obligated to make factual determinations by a preponderance of the evidence).

97. *Conyers v. State*, 354 Md. 132, 170, 729 A.2d 910, 930 (1999).

exist, then the court or the jury must determine, also by a preponderance of the evidence, whether any aggravating circumstances outweigh the mitigating circumstances when determining the sentence.⁹⁸

3. Analysis of Admissibility of Functional Magnetic Resonance Imaging Evidence of Brain Impairment or Malformation as a Mitigating Factor During Sentencing Under a Preponderance of the Evidence Standard

The criminal law is based on the premise that mental states have an effect on the determination of the appropriate punishment.⁹⁹ Federal law and Maryland state law make it clear that the court must consider all possible information concerning the defendant's life and characteristics, without limitation, in order to determine an appropriate sentence for both the individual and the crime.¹⁰⁰ Mitigating factors explicitly allow a judge or jury to consider whether the crime was committed while the defendant was unable to appreciate the criminality of the conduct or to conform the conduct to the requirements of law due to mental disorder or mental incapacity.¹⁰¹ As such, fMRI evidence providing insight into the biological causes of a defendant's increased aggression and violence or decreased ability to perceive and understand the culpability and criminality of his or her actions should be admissible as a mitigating factor during sentencing proceedings.¹⁰²

While it is true that the existence of mitigating factors must be proven by a preponderance of the evidence,¹⁰³ correlative fMRI research has shown that individuals known to have increased violent and aggressive behavioral tendencies will more likely than not show increased brain activity in the amygdala and decreased brain activity in the prefrontal cortex.¹⁰⁴ Thus, a defendant should be allowed to

98. MD. CRIM. LAW § 2-303(i)(1).

99. See *Garnett v. State*, 332 Md. 571, 576–79, 632 A.2d 797, 800–01 (1993).

100. 18 U.S.C. § 3661 (2006); *Pepper v. United States*, 131 S. Ct. 1229, 1240 (2011); *Williams v. New York*, 337 U.S. 241, 247 (1949).

101. MD. CRIM. LAW § 2-303(h)(2)(iv).

102. See *Batts*, *supra* note 1, at 264, 269; *cf.* 18 U.S.C. § 3661 ("Use of information for sentencing"); MD. CRIM. LAW § 2-303(h)(2)(iv) ("Consideration of mitigating circumstances.").

103. See *supra* note 96 and accompanying text.

104. Mairead C. Dolan, *What Imaging Tells Us About Violence in Anti-Social Men*, 20 CRIM. BEHAV. & MENTAL HEALTH 199, 207–08 (2010) (citing studies that prove individuals prone to reactive aggression have exaggerated amygdala responses and attenuated prefrontal activation during performance of an inhibition task, as compared

introduce evidence of fMRI scans of his or her brain activity.¹⁰⁵ Showing increased activation of the amygdala or decreased activity of the prefrontal cortex is appropriate for consideration as a mitigating factor¹⁰⁶ because such biological impairments are a characteristic of the defendant and play a direct role in the inability of the defendant to comprehend the criminality of his or her actions.¹⁰⁷ The mental state of the defendant must be considered to ensure the punishment for the crime is tailored to the individual.¹⁰⁸

4. Risks Associated With Use of Functional Magnetic Resonance Imaging Evidence of Brain Impairment or Malformation as a Mitigating Factor During Sentencing

There are, however, some risks associated with use of fMRI evidence as a mitigating factor.¹⁰⁹ One such concern is the human error and subjectivity or bias associated with the analysis of the brain images.¹¹⁰ Although scientists, technicians, and clinicians choose which technique to use,¹¹¹ some subjectivity and bias is eliminated because very precise computer algorithms quantitatively analyze the fMRI data.¹¹² This results in a more accurate determination of whether the defendant's brain is structurally and functionally impaired.¹¹³ Furthermore, this method of analysis permits a comparison of the defendant's brain to a database of fMRI data from brains with known abnormalities.¹¹⁴

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- to individuals with healthy controls); *see also* Adrian Raine et al., *Reduced Right Hemisphere Activation in Severely Abused Violent Offenders During a Working Memory Task: An fMRI study*, 27 *AGGRESSIVE BEHAV.* 111, 124 (2001) (“Seriously violent individuals who have suffered severe physical abuse as children show reduced functioning . . . [in] the right temporal cortex[.]”).
105. *See* Dolan, *supra* note 104, at 207–08; Raine et al., *supra* note 104, at 124; *cf.* 18 U.S.C. § 3661 (discussing the “use of information for sentencing”).
106. *Cf.* Conyers v. State, 354 Md. 132, 170, 729 A.2d 910, 930 (1999) (suggesting that anything about the defendant or the facts of the case should be considered as a mitigating circumstance out of fairness or mercy to the defendant in sentencing).
107. *See* 18 U.S.C. § 3661; Conyers, 354 Md. at 170, 729 A.2d at 930.
108. *See supra* Part III.B.1–2.
109. *See generally* John H. Blume & Emily C. Paavola, *Life, Death, and Neuroimaging: The Advantages and Disadvantages of the Defense’s Use of Neuroimages in Capital Cases – Lessons From the Front*, 62 *MERCER L. REV.* 909 (2011) (discussing the considerations that need to be made when neuroimaging is used in a capital case).
110. *Id.* at 925.
111. *See* Joseph H. Baskin et al., *Is a Picture Worth a Thousand Words? Neuroimaging in the Courtroom*, 33 *AM. J.L. & MED.* 239, 249 (2007).
112. *See* Gore, *supra* note 9, at 925.
113. Blume & Paavola, *supra* note 109, at 914.
114. *Id.*

Another concern regarding the use of fMRI evidence is its effect on judicial and juror decision making.¹¹⁵ Unless the fMRI results, and the behavioral and clinical significance of those results, are clearly explained so that judges and laypersons on the jury can understand the implications for the defendant in terms of the crime committed, then judges or jurors may give improper weight to the fMRI evidence.¹¹⁶

5. Aggravation and Sentencing

The consideration of aggravating factors also allows the court to individualize the defendant's sentence in order "to fit the 'offender, and not merely the crime.'"¹¹⁷ The court may consider various factors, including the defendant's attitude at trial,¹¹⁸ "reputation, . . . health, habits, [and] mental and moral propensities."¹¹⁹ It is also well settled in both federal and Maryland state courts that the State has the burden of raising any aggravating factors to be considered during sentencing, and the standard of proof for such aggravating factors is beyond a reasonable doubt.¹²⁰

6. Analysis of Admissibility of Functional Magnetic Resonance Imaging Evidence of Brain Impairment or Malformation as an Aggravating Factor During Sentencing Under a Beyond a Reasonable Doubt Standard

Mental states have an effect on the determination of the appropriate punishment for a crime.¹²¹ However, the existence of aggravating

115. *See id.* at 927.

116. *See id.* One research study introduced fMRI evidence to a mock jury in order to see how such evidence would affect decision making. Fabian, *supra* note 11, at 219. The results of the study concluded that jurors are 15% more likely to find a defendant not guilty by reason of insanity when such a plea is accompanied by a brain imaging. *Id.* It is important to note, however, that this study involved admission of fMRI as substantive evidence during the guilt phase. *See id.* Risk of an improper acquittal is not present when fMRI evidence is introduced only as a mitigating factor during sentencing.

117. *Jennings v. State*, 339 Md. 675, 683, 664 A.2d 903, 907 (1995) (quoting *Smith v. State*, 308 Md. 162, 167, 517 A.2d 1081, 1084 (1986)).

118. *Id.* at 688, 664 A.2d at 910; *Saenz v. State*, 94 Md. App. 238, 250–51, 620 A.2d 725, 736 (1993).

119. *Colvin-el v. State*, 332 Md. 144, 166, 630 A.2d 725, 736 (1993) (quoting *Huffington v. State*, 304 Md. 559, 577, 500 A.2d 272, 281 (1985)).

120. 18 U.S.C. § 3593(c)(2006); MD. CODE ANN. CRIM. LAW § 2-303(g)(1) (LexisNexis 2012).

121. *See Garnett v. State*, 332 Md. 571, 577–87, 632 A.2d 797, 800–01 (1993).

factors must be proven beyond a reasonable doubt in order for them to be taken into consideration during sentencing.¹²² Correlative fMRI research has shown that individuals known to have increased violent and aggressive behavioral traits show increased brain activity in the amygdala and decreased brain activity in the prefrontal cortex and are more likely than not unable to control their behavior or appreciate the criminality of their actions.¹²³ But the fMRI research results are not yet equivalent to the beyond a reasonable doubt standard required for the escalation or enhancement of the defendant's punishment.¹²⁴ The concerns regarding the difficulty in measuring the BOLD responses and the effect of variations of blood components on the BOLD responses prohibit this technology from meeting the beyond a reasonable doubt standard required for admission as an aggravating factor.¹²⁵

IV. THE BIGGER QUESTION MOVING FORWARD: WHAT ROLE WILL FUNCTIONAL MAGNETIC RESONANCE IMAGING PLAY IN THE FUTURE AS TECHNOLOGY ADVANCES?

A. *The Fabric of the Criminal Law*

The criminal law is based on the premise that there are two components to every crime: the *actus reus*, the forbidden criminal act, and the *mens rea*, the guilty mind or intent accompanying the criminal act.¹²⁶ Thus, the mental state of the defendant relates directly to the criminal culpability of the defendant, and to the determination of the appropriate punishment to fit both the defendant and the crime.¹²⁷ Identifying the defendant's state of mind, however, is a difficult task.¹²⁸ Currently, courts must rely on objective circumstances surrounding the conduct of the defendant in order to infer the defendant's state of mind.¹²⁹ In the near future, however, as technology advances and research continues, fMRI technology should reach a point where it can be used to identify the defendant's mental state at the time of committing the crime.¹³⁰ For this reason, it

122. 18 U.S.C. § 3593(c); MD. CRIM. LAW § 2-303(g)(1).

123. See *supra* note 104 and accompanying text; *supra* Part III.B.1.

124. See *supra* Part II.C.

125. See *supra* Part II.C.

126. *Garnett*, 332 Md. at 577-78, 632 A.2d at 800.

127. See *id.* at 577-79, 632 A.2d at 800-01.

128. *Brown & Murphy*, *supra* note 19, at 1130.

129. *Id.*

130. See *Appelbaum*, *supra* note 11, at 461-62.

is important for judges, lawyers, neuroscientists, and lawmakers to consider the concerns raised by the potential use of such fMRI evidence, and what role fMRI evidence will play in the law in the future.¹³¹

B. Functional Magnetic Resonance Imaging as an Aggravating Factor or as Substantive Evidence for Determining Guilt

fMRI technology and research have evolved to the point where evidence of increased activation of the amygdala or decreased activity of the prefrontal cortex proves, more likely than not, that an individual is predisposed to aggressive or violent behavior and that the individual has a decreased ability to perceive and understand the culpability and criminality of his or her actions.¹³² Thus, the use of such fMRI evidence as a mitigating factor, which requires only a preponderance of the evidence standard, is consistent with the fabric of the criminal law that states that if a defendant lacks the mental capacity to conform his or her conduct to the law then the defendant's sentence should be mitigated.¹³³

However, when fMRI technology evolves to the point where it can prove an individual's mental state beyond a reasonable doubt, the use of fMRI evidence seems to pose significant problems for the principles of criminal law and the criminal justice system.¹³⁴ The use of fMRI evidence as an aggravating factor may be at odds with the legal principle that justifies aggravating factors, because an individual cannot control or change the functioning of his or her brain.¹³⁵ It does not seem just or fair to increase the punishment of a defendant who can neither control his or her actions nor appreciate the criminality of his or her behavior. Furthermore, the use of fMRI evidence to determine guilt or innocence seems to raise fundamental questions as to the very definitions of guilt and innocence, as biological impairment has a direct impact on the legal concept of responsibility.¹³⁶ If an individual cannot appreciate the fact that engaging in certain conduct is wrong or criminal, then the individual cannot form the requisite *mens rea* necessary for conviction of the crime committed, and this suggests that the individual is not guilty of the crime, despite the fact that the *actus reus* is unquestionably

131. *See id.*

132. *See supra* Part III.B.3.

133. MD. CODE ANN., CRIM. LAW § 2-303(h)(2) (LexisNexis 2012).

134. *See Brown & Murphy, supra* note 19, at 1132.

135. *See, e.g., Batts, supra* note 1, at 264–65.

136. *See Brown & Murphy, supra* note 19, at 1134–35.

present.¹³⁷ The use of such evidence also poses a concern because if two individuals commit the very same crime, is it just to punish only one of them if fMRI evidence shows that the other has an improperly functioning brain? Such concerns should be addressed through policy and the development of a legal framework before technology inevitably advances, “rather than through the adjudication of specific cases relying on individualized facts.”¹³⁸

V. CONCLUSION

FMRI as a method of distinguishing truth from falsehood does not meet either the *Daubert* multi-factor analysis or the *Frye* general acceptance standard for use as substantive evidence in court.¹³⁹ FMRI evidence of lie detection fails these standards for admissibility because the research results from group-based studies are not yet consistent enough to make individualized determinations of truth versus falsehood, due to the variability and complexities involved in the brain patterns associated with different forms of lying.¹⁴⁰ With continued scientific research, however, fMRI evidence of deception will meet the *Daubert* and *Frye* standards for admission in the future.¹⁴¹

FMRI evidence of increased violence and aggression resulting from functional impairment of the amygdala and the prefrontal cortex region of the brain, however, meets the preponderance of the evidence standard required for the admissibility of evidence during a sentencing proceeding.¹⁴² Therefore, the court and the jury should consider fMRI evidence as a mitigating factor during sentencing, as long as such evidence is viewed with caution and presented in such a manner that a layperson can clearly understand the clinical findings and the corresponding behavioral implications for the defendant in terms of his or her criminal culpability.¹⁴³ It is important to note, however, that such fMRI evidence does not meet the beyond a reasonable doubt standard that is required for admission as an aggravating factor.¹⁴⁴

As science advances, however, fMRI technology should evolve to the point where such evidence can meet the beyond a reasonable

137. See *Garnett v. State*, 332 Md. 571, 577–78, 632 A.2d 797, 800 (1993).

138. See *Brown & Murphy*, *supra* note 129, at 1135.

139. See *supra* Part III.A.2–3.

140. See *supra* Part III.A.2–3.

141. See *Appelbaum*, *supra* note 11, at 461.

142. See *supra* Part III.B.3.

143. See *supra* Part III.B.3; *supra* note 116 and accompanying text.

144. See *supra* Part III.B.6.

doubt standard required for admission as an aggravating factor and, perhaps even more troubling, to the point where such fMRI evidence is reliable enough to meet the *Daubert* and *Frye-Reed* tests for admissibility as substantive evidence for the determination of guilt.¹⁴⁵ For this reason, courts should anticipate encountering such fMRI brain evidence sooner rather than later so that when the fMRI technology advances, the groundwork for the use of fMRI evidence in the legal system has already been laid.¹⁴⁶

*Kristina E. Donahue**

145. See Appelbaum, *supra* note 11, at 461–62.

146. See *id.*

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