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Misdiagnosing the Impact of Neuroimages in the Courtroom

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ABSTRACT

Neuroimages and, more generally, neuroscience evidence are increasingly used in the courtroom in hope of mitigating punishment in criminal cases. Many legal commentators express concern because they fear that the prejudicial effect of such evidence significantly outweighs its probative value. In light of earlier empirical studies, this concern is predominantly directed toward the visual impact of neuroimages. Thus, the conventional wisdom in the legal literature is that the visual impact of neuroimages drives the overpersuasiveness of neuroscience evidence.

However, recent empirical studies draw into question the conventional wisdom because they show that neuroimages themselves are not overly persuasive. Thus, this Comment proposes a new theory—the structure/function paradigm—as a competing theory to the conventional wisdom. This paradigm posits that the type of brain abnormality drives the prejudicial nature of neuroscience evidence, not the visual impact of neuroimages. That is, laypeople perceive structural and functional brain abnormalities differently and view structural abnormalities as more causally potent than functional abnormalities. This Comment seeks to show that the structure/function paradigm provides a more consistent and compelling story than the conventional wisdom by resolving contradictions in the empirical studies and applying the paradigm to actual cases.

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61 UCLA L. Rev. 1502 (2014)

TABLE OF CONTENTS

INTRODUCTION

Throughout history, people have attempted to discover the biological basis for criminal and violent behavior. In the early nineteenth century, Franz Joseph Gall tried to predict criminality based on phrenology, which links particular behavioral traits to skull protuberances.[1] In the latter half of that century, Cesare Lombroso propagated the idea of physiognomy, which proposes that criminality can be predicted by observing physical characteristics, especially facial features, such as strong jaws, heavy brows, and thick lips.[2] Although both theories have fallen into disrepute, recent advances in neuroscience have used neuroimaging to link structural and functional abnormalities in the brain to certain antisocial behaviors.[3] For this reason, neuroscience evidence is increasingly used to argue that the defendant has an inherent, biological abnormality, which reduces his responsibility and should serve as a mitigating factor in sentencing decisions.

In 1985, *Ake v. Oklahoma*[4] opened the door for such neuroscience evidence in criminal cases.[5] In *Ake*, the U.S. Supreme Court held that due process under the Fourteenth Amendment requires that an indigent defendant have access to a psychiatric evaluation when his sanity is in question.[6] Neuroscience evidence based on neuroimaging and on other neurological tests is included in the realm of such psychiatric testimony.[7] Thus, a number of criminal defendants have sought to introduce neuroscience evidence to support not only insanity defenses,[8] but also claims of incompetency to stand trial[9] and of mitigation during the sentencing phase.[10] These defendants sought to introduce neuroscience evidence in one of

1. *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, 174 (2007); Amanda C. Pustilnik, *Violence on the Brain: A Critique of Neuroscience in Criminal Law*, 44 WAKE FOREST L. REV. 183, 191 (2009).
2. *See* William Bernet et al., *Bad Nature, Bad Nurture, and Testimony Regarding* MAOA *and* SLC6A4 *Genotyping at Murder Trials*, 52 J. FORENSIC SCI. 1362, 1362 (2007); Khoshbin & Khoshbin, *supra* note 1, 173–74; Pustilnik, *supra* note 1, at 195–96.
3. *See infra* Part I.B; *cf.* Nikos K. Logothetis, *What We Can Do and What We Cannot Do With fMRI*, 453 NATURE 869, 869 (2008) (noting that functional magnetic resonance imaging ("fMRI") is used to draw conclusions about the biological mechanisms of human cognitive capabilities, including reflecting on ethical dilemmas).
4. 470 U.S. 68 (1985).
5. *See* Purvak Patel et al., *The Role of Imaging in United States Courtrooms*, 17 NEUROIMAGING CLINICS N. AM. 557, 558 (2007).
6. *Ake*, 470 U.S. at 83.
7. *See* Patel et al., *supra* note 5, at 558.
8. *See, e.g.,* People v. Weinstein, 591 N.Y.S.2d 715, 723–24 (Sup. Ct. 1992).
9. *See, e.g.*, United States v. Gigante, 166 F.3d 75, 84 (2d Cir. 1999).
10. *See, e.g.*, People v. Holt, 937 P.2d 213, 231 (Cal. 1997).

two forms: general neuroscience evidence (which will refer to neuroscience evidence that draws its inferences and conclusions from the neuroimage, but does not use the actual neuroimage itself),[11] or neuroimaging evidence (which will refer to neuroscience evidence with neuroimages).[12]

Surprisingly, a significant number of criminal defendants have successfully introduced neuroscience evidence in either of the two forms.[13] As of 2006, there were 133 reported state and federal opinions involving evidence using neuroimaging technology, specifically position emission tomography (PET) or single-photon emission computed tomography (SPECT).[14] A recent search shows that there are 330 criminal cases involving PET, SPECT, or functional magnetic resonance imaging (fMRI),[15] which is another type of neuroimaging technology.[16]

As an increasing number of defendants rely on neuroscience evidence, many members of the legal community express concerns about the potential misuse of such evidence in the courtroom. They fear that both judges and juries

11. For example, general neuroscience evidence may include verbal expert testimony about what was found in a neuroimage, but does not include the presentation of the neuroimage. *See* Virginia Hughes, *Head Case*, 464 NATURE 340, 341 (2010).

12. *See, e.g.*, *Gigante*, 166 F.3d at 84 (affirming the trial court's decision regarding the defendant's competency to stand trial even though the trial court considered neuroscience evidence with the neuroimage that allegedly showed the defendant had Alzheimer's disease); *Holt*, 937 P.2d at 231(admitting the defendant's neuroscience evidence with the neuroimage that purportedly showed that the defendant's low metabolic brain activity was the cause of the defendant's aberrant behavior); *Weinstein*, 591 N.Y.S.2d at 723–24 (admitting the defendant's neuroscience evidence with the neuroimage that showed that the defendant had brain abnormalities that prevented him from distinguishing between right and wrong); Hughes, *supra* note 11, at 341 (noting that during the sentencing phase of the defendant's trial, the defendant's expert witness was only permitted to introduce general neuroscience evidence (i.e. neuroscience evidence without the neuroimage) but not the actual neuroimage).

13. *See* President's Council on Bioethics, *An Overview of the Impact of Neuroscience Evidence in Criminal Law* (Sept. 2004) (working paper), *available at* http://bioethics.georgetown.edu/pcbe/background/neuroscience_evidence.html.

14. Neal Feigenson, *Brain Imaging and Courtroom Evidence: On the Admissibility and Persuasiveness of fMRI*, 2 INT'L J.L. CONTEXT 233, 237 (2006). In eighty-five out of the 133 cases, the party presented or sought to present it to judges, not to juries. *Id.* Additionally, in eighty-nine of the 133 cases, the question of whether the positron emission topography (PET) or single-photon emission computed tomography (SPECT) evidence should be admitted or excluded was addressed. *Id.* Out of those eighty-nine cases, the neuroimaging evidence was admitted in seventy-three of them. *Id.* See *infra* Part I.A for a discussion of different types of neuroimaging technology.

15. Cases were identified using WestlawNext and the following search string: (PET or SPECT or fMRI) /15 (scan! or image!). The results were filtered by jurisdiction: federal (U.S. Supreme Court, Court of Appeals, and District Court) and topic: criminal. This search was last updated on Oct. 27, 2012. This number rises to around 1100 criminal cases when computed tomography (CT) scans of the brain are included in this search.

16. Cases were identified using WestlawNext and the following search string: brain and (CT or PET or SPECT or fMRI) /15 (scan! or image!). The results were filtered by jurisdiction: federal (Court of Appeals and District Court) and topic: criminal. This search was last updated on Oct. 27, 2012.

are subject to what Stephen J. Morse coins the "brain overclaim syndrome:" making moral and legal claims that neuroscience research does not necessarily support.[17] Specifically, there is concern that such evidence will erroneously impact jurors' judgments about the defendant's responsibility, state of mind, and future dangerousness in criminal cases.[18] This fear was even expressed during Chief Justice Roberts's confirmation hearing, when then-Senator Joe Biden asked whether Chief Justice Roberts thought "brain scans [could] be used to determine whether a person is inclined toward criminality or violent behavior."[19] Biden's question highlights the apprehension over neuroscience evidence and suggests that this issue may arise during Chief Justice Roberts's time on the Supreme Court.[20]

The concerns about general neuroscience evidence appear to be well grounded. A number of empirical studies show that presenting general neuroscience evidence is overpersuasive.[21] Thus, members of the legal community are wary that the probative value of such evidence is outweighed by its capacity to prejudice or confuse the jury or the judge—especially during sentencing decisions.[22] Still others express qualms about introducing such evidence because it purports to localize complex human behavior to a single area in the brain.[23]

Yet in much of the legal literature, the principal concern is with the actual neuroimage itself. Many legal commentators attribute the overpersuasiveness of neuroscience evidence to neuroimages and conclude that neuroimages themselves are extremely prejudicial and lack probative value.[24] They fear that

17. Jeffrey Rosen, *The Brain on the Stand*, N.Y. TIMES MAG. (Mar. 11, 2007), http://www.nytimes.com/2007/03/11/magazine/11Neurolaw.t.html.
18. *See* 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, 335 (2010).
19. *Id.* at 334–35. (internal quotation marks omitted).
20. *Id.* at 335.
21. *See infra* Part II.
22. *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, 1155 (2010); Compton, *supra* note 18, at 3354; Jennifer Kulynych, Note, *Psychiatric Neuroimaging Evidence: A High-Tech Crystal Ball?*, 49 STAN. L. REV. 1249, 1251 (1997) [hereinafter Kulynych, *Psychiatric Neuroimaging Evidence*]. Some legal commentators are fearful that the evidence could also be used as an aggravating factor that indicates future dangerousness. *See* Abram S. Barth, Note, *A Double-Edged Sword: The Role of Neuroimaging in Federal Capital Sentencing*, 33 AM. J.L. & MED. 501, 520 (2007). But it appears that most are concerned that neuroimages will be introduced by the defense to mitigate sentences. *See* Shelley Batts, *Brain Lesions and Their Implications in Criminal Responsibility*, 27 BEHAV. SCI. & L. 261, 271 (2009).
23. *See* Paul S. Appelbaum, *Through a Glass Darkly: Functional Neuroimaging Evidence Enters the Courtroom*, 60 PSYCHIATRIC SERVICES 21, 22 (2009).
24. *See infra* Part II.

neuroimages hold a "seductive allure" over the minds of jurors because of their powerful visual nature.[25] Thus, the conventional wisdom in the legal literature is that the visual impact of neuroimages drives the overpersuasiveness of neuroscience evidence.

The purpose of this Comment is to evaluate whether the visual impact of neuroimages affects jurors' and judges' perceptions of a criminal defendant's responsibility and culpability, such that the neuroimages lead to reduced punishment during sentencing decisions.[26] Although supporters of the conventional wisdom point to a number of empirical studies finding neuroimages unduly influence jurors, other recent studies reach the opposite result[27]—that is, that neuroimages have no independent effect on laypeople's judgments.[28] Thus, this Comment argues that the conventional wisdom is flawed because it does not appear that neuroimages hold that "seductive allure" over laypeople's minds after all. The overpersuasiveness of neuroscience evidence is not due to the visual impact of the neuroimage.

Instead, this Comment proposes a new paradigm—the structure/function paradigm—as a better explanation of the persuasive power of neuroscience evidence. The structure/function paradigm demonstrates that the overly persuasive power of neuroscience evidence is attributable to the type of brain abnormality rather than the neuroimage's visual impact. The paradigm suggests that laypeople perceive structural abnormalities as more causally determinative of aberrant behavior than functional abnormalities. By applying this new paradigm to empirical studies and to past cases in which such neuroscience evidence was introduced, this Comment seeks to resolve the inconsistencies that result when explaining these studies and cases according to conventional wisdom. Thus, this Comment recommends that instead of being blinded by fear of the neuroimage itself, we

25. *See infra* Part II.

26. The term sentencing decisions will refer to both sentencing in capital and noncapital cases in this Comment.

27. *See, e.g.*, David Gruber & Jacob A. Dickerson, *Persuasive Images in Popular Science: Testing Judgments of Scientific Reasoning and Credibility*, 21 PUB. UNDERSTANDING SCI. 938 (2012); Cayce J. Hook & Martha J. Farah, *Look Again: Effects of Brain Images and Mind-Brain Dualism on Lay Evaluations of Research*, 25 J. COGNITIVE NEUROSCIENCE 1397 (2013); Robert B. Michael et al., *On the (Non)persuasive Power of a Brain Image*, 20 PSYCHONOMIC BULL. & REV. 720 (2013); N.J. Schweitzer et al., *Fooled by the Brain: Re-examining the Influence of Neuroimages*, 129 COGNITION 501 (2013) [hereinafter Schweitzer et al.]; N.J. Schweitzer & Michael J. Saks, *Neuroimage Evidence and the Insanity Defense*, 29 BEHAV. SCI. & L. 592, 594 (2011) [hereinafter Schweitzer & Saks].

28. *See* Adina L. Roskies, N.J. Schweitzer & Michael J. Saks, *Neuroimages in Court: Less Biasing than Feared*, 17 TRENDS COGNITIVE SCI. 99 (2013).

should shift our concern to the type of brain abnormality and should be more wary of evidence linking structural abnormalities to aberrant behavior.

The arguments in this Comment are narrowly aimed at the admission of neuroimaging evidence during the sentencing phase.[29] This Comment focuses on the sentencing phase because that is when such evidence will most likely be admitted, since the evidentiary rules are relaxed compared to the guilt-innocence phase.[30] The standards for admitting and evaluating mitigating or aggravating evidence are much more flexible than those used for affirmative defenses (such as insanity and diminished responsibility).[31] For example, in capital cases, the Supreme Court has clearly established that during the sentencing phase, "the sentencer may not refuse to consider or be precluded from considering any relevant mitigating evidence."[32]

Part I is a primer providing a basic introduction to neuroimaging technology as well as legally relevant neuroscience research that uses neuroimaging to link brain abnormalities to aberrant behavior. Part II first introduces two empirical studies that show that general neuroscience evidence influences laypeople's judgments. Laypeople perceive explanations based on neuroscience as significantly more satisfying than other common explanations. This effect translates into real-world consequences in the courtroom by leading laypeople to impose

29. I would like to note, however, that some of these arguments can be generalized to mens rea claims during the guilt-innocence phase of a criminal trial.

30. "In resolving any dispute concerning a factor important to the sentencing determination, the court may consider relevant information without regard to its admissibility under the rules of evidence applicable at trial, provided that the information has sufficient indicia of reliability to support its probable accuracy." U.S. SENTENCING COMM'N, GUIDELINES MANUAL § 6A1.3(a) (2013).

31. Deborah W. Denno, *Behavioral Genetics Evidence in Criminal Cases: 1994–2007*, *in* THE IMPACT OF BEHAVIORAL SCIENCES ON CRIMINAL LAW 317, 332 (Nita A. Farahany ed., 2009). In both capital and noncapital cases, the criteria for admission of mitigating and aggravating factors are far broader. Stephen J. Morse, *Gene-Environment Interactions, Criminal Responsibility, and Sentencing*, *in* GENE-ENVIRONMENT INTERACTIONS IN DEVELOPMENTAL PSYCHOPATHOLOGY 207, 229 (Kenneth A. Dodge & Michael Rutter eds., 2011). For example, in capital cases the Eighth and Fourteenth Amendments require that the sentencer is not precluded from considering the defendant's "character or record and any of the circumstances of the offense that the defendant proffers as a basis for a sentence less than death." Lockett v. Ohio, 438 U.S. 586, 604 (1978) (plurality opinion). See 18 U.S.C. § 3592, which lays out the federal statutory mitigating and aggravating factors that are considered in capital cases to determine whether the death penalty is justified. 18 U.S.C. § 3592 (2006). Although in most jurisdictions the aggravating factors must outweigh the mitigating factors in order for a defendant to receive the death penalty, the Supreme Court has upheld a death penalty statute that allowed jurors to impose the death penalty when the aggravating factors did not outweigh the mitigating factors. *See* Kansas v. Marsh, 548 U.S. 163, 181 (2006); *see also* Deborah W. Denno, *Courts' Increasing Consideration of Behavioral Genetics Evidence in Criminal Cases: Results of a Longitudinal Study*, 2011 MICH. ST. L. REV. 967, 977 (2011).

32. Hitchcock v. Dugger, 481 U.S. 393, 394 (1987) (internal quotation marks omitted).

reduced prison sentences or by increasing the frequency of not guilty by reason of insanity (NGRI) verdicts. Part II then lays out the conventional wisdom that the visual impact of neuroimages drives the overpersuasiveness of neuroscience evidence. Various theories about the visual features of neuroimages are detailed and supported by empirical studies that show that these visual features may influence people's perceptions. Part III outlines empirical studies that directly counter the studies in Part II. The studies in Part III call into doubt whether the neuroimage itself drives changes in jurors' perceptions.

Part IV presents a new theory, the structure/function paradigm, as what may truly drive the overpersuasiveness of neuroscience evidence: that is, structural abnormalities, not functional abnormalities. This Part shows that regardless of the neuroimage itself, laypeople perceive structural brain abnormalities to have a higher causal potency than functional abnormalities in determining aberrant behavior. Additionally, Part IV uses the structure/function paradigm to reevaluate the empirical studies discussed in Parts II and III. Part IV also applies the structure/function paradigm to five cases that are overwhelmingly cited in support of the conventional wisdom that neuroimages are overpersuasive. This Part shows that these cases actually do not support the conventional wisdom and are rather better explained under the structure/function paradigm.

Lastly, Part V provides a recommendation for judges who may confront evidence of structural abnormalities linked to aberrant behavior during the sentencing phase of a trial. This Part points out that there are two specific times during the sentencing phase when the judge can work to mitigate the prejudicial nature of such evidence: first, when counsel seeks to introduce the evidence, and second, if the evidence is deemed admissible, during the jury instructions. This Part also calls for judges to be more proactive, to diversify their reading materials to include relevant neuroscience literature, and to keep up-to-date with neuroscience research.

I. THE SCIENCE OF NEUROSCIENCE EVIDENCE: NEUROIMAGING TECHNOLOGY AND EMPIRICAL NEUROSCIENCE STUDIES USING NEUROIMAGING

Part I provides a primer that gives a basic introduction to different types of neuroimaging technologies and relevant neuroscience research using neuroimaging.

A. The Basics of Neuroimaging Technology

1. Structural Imaging

Computerized tomography (CT) scans of the brain show the gross anatomical structure of the brain and the skull.[33] This type of scan relies on X-ray beam technology and a computer-imaging program to develop the scan.[34] Series of X-rays are taken from multiple directions and are used to reconstruct the image based on the density of different structures in the brain.[35]

Another method of imaging the brain structure is magnetic resonance imaging (MRI). MRI provides better contrast resolution (the ability to differentiate between structures of different compositions) than CT scans.[36] This type of scan uses electromagnetic waves, which the protons in the brain absorb and reradiate.[37] The intensity of the signal strength from the reradiated waves depends on the type of soft tissue in the brain.[38] The location of each signal is then assigned to a specific location on the scan.[39] The resulting scan is a map in which different tissues are characterized by different signal intensities, which appear brighter or darker on the scan.[40]

Both CT and MRI scans can be either two-dimensional or three-dimensional images of the brain.[41]

2. Functional Imaging

Position emission tomography (PET) and single-photon emission computed tomography (SPECT) are both used to image the brain's functional activity.[42]

33. *See, e.g.*, Erin D. Bigler, Mark Allen & Gary K. Stimac, *MRI and Functional MRI*, *in* NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM 27, 29 (Joseph R. Simpson ed., 2012).
34. *Id.*
35. *Id.*; *see also* RONALD L. EISENBERG, RADIOLOGY: AN ILLUSTRATED HISTORY 469 (Anne S. Patterson ed., 1992).
36. Bigler, Allen & Stimac, *supra* note 33, at 29.
37. *Id.*
38. For example, structures with high water content, such as tumors, have longer signal strengths. *Id.*
39. *Id.*
40. *Id.*
41. *Id.* at 32; *see also* EISENBERG, *supra* note 35, at 470–71.
42. For an extended discussion about PET and SPECT technology, see Susan E. Rushing, Daniel A. Pryma & Daniel D. Langleben, *PET and SPECT*, *in* NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM 3 (Joseph R. Simpson ed., 2012).

In PET and SPECT, a radioactive tracer is injected into a person.[43] The tracer undergoes radioactive decay and emits gamma rays, which the scanner's cameras detect.[44] PET and SPECT differ in the type of radioactive tracers they use, the way they detect the emitted signals, and the method in which the data is reconstructed into an image.[45] SPECT is technically simpler and is less expensive than PET, but has lower spatial and temporal resolution than PET.[46]

Functional magnetic resonance imaging (fMRI) is a relatively newer method of measuring brain activity. fMRI uses blood oxygenation level-dependent (BOLD) contrast. BOLD measures the change in blood flow (also known as the "hemodynamic response"), which is related to the oxygen use in the brain.[47] As a region in the brain metabolizes, more oxygen flows into that area.[48] Metabolism is known to be associated with increased activity in the brain.[49] Thus, when a region of the brain is activated, more oxygen is supplied to that region and the ratio of oxygenated to deoxygenated blood increases.[50] fMRI measures the oxygenated blood, which translates into changes in signal intensity.[51]

B. Empirical Neuroscience Studies

Neuroscience research has used these different neuroimaging techniques to link both structural abnormalities and functional abnormalities in the brain to aberrant behavior. Structural abnormalities are defined as changes in gross anatomical structure such as losses of volume, tumors, or lesions in the brain.[52]

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43. *See, e.g.*, Michael E. Phelps, *Positron Emission Tomography Provides Molecular Imaging of Biological Processes*, 97 PROC. NAT'L. ACAD. SCI. U.S. 9226, 9226 (2000); Rushing, Pryma & Langleben, *supra* note 42, at 3.
44. Rushing, Pryma & Langleben, *supra* note 42, at 3.
45. *Id.*
46. *Id.* Spatial resolution is defined as how far apart two points need to be in order to be seen as two separate points and not as a single point. *Id.* at 11 (noting that this is critical to determine whether a finding is seen). Temporal resolution is defined as the precision of measurement with respect to time. Brown & Murphy, *supra* note 22, at 1136 n.62.
47. *See, e.g.*, S. Ogawa et al., *Brain Magnetic Resonance Imaging with Contrast Dependent on Blood Oxygenation*, 87 PROC. NAT'L ACAD. SCI. U.S. 9868, 9868 (1990).
48. *See, e.g.*, Feigenson, *supra* note 14, at 234; *cf.* Logothetis, *supra* note 3, at 870 (noting that the functional activation can be detected by changes in oxygen concentration in the brain).
49. *See, e.g.*, Patel, *supra* note 5, at 559–60.
50. Feigenson, *supra* note 14, at 234.
51. *See, e.g.*, Ogawa, *supra* note 47, at 9868.
52. *See* Jacqueline Foong et al., *Neuropathological Abnormalities in Schizophrenia: Evidence From Magnetization Transfer Imaging*, 124 BRAIN 882, 882 (2001) (defining structural abnormalities). Structural abnormalities have been implicated in aberrant behavior. *See* Larry J. Siever, *Neurobiology of Aggression and Violence*, 165 AM. J. PSYCHIATRY 429, 432 (2008) (noting that lesions and tumors in either the prefrontal cortex or the temporal lobe have been implicated in aggressive and violent behavior); Joseph M. Tonkonogy & Jeffrey L. Geller, *Hypothalamic Lesions*

Functional abnormalities are defined as abnormal brain activity in response to a stimulus, such as lower-than-normal activation levels in a certain area of the brain during a behavioral task.[53]

With these two different types of brain abnormalities in mind, this Subpart proceeds to focus on two areas in the brain that have been consistently implicated in aggressive, impulsive behavior as well as in antisocial personality disorder (which is characterized by aggressive and impulsive behavior)[54] and in psychopathy. Such aberrant behavior and disorders are most relevant to our discussion because the associated symptoms indicate the defendant may have less control over his actions. Thus, this type of evidence is most likely introduced as a mitigating factor to show that the defendant is less culpable and less responsible for his behavior because of a biological abnormality in his brain and therefore that he should be punished less severely.

1. Prefrontal Cortex

The first of the two areas in the brain that have been associated with behavioral changes is the prefrontal cortex.[55] The prefrontal cortex mediates executive functions, which are the "ability to coordinate thought and action and direct it toward obtaining goals."[56] Some of these executive functions include the ability

and Intermittent Explosive Disorder, 4 J. NEUROPSYCHIATRY & CLINICAL NEUROSCIENCES 45, 45–47 (1992) (presenting two patient cases, both diagnosed with intermittent explosive disorder under the DSM-III-R criteria and presenting hypothalamic lesions in the brain, which were proposed as a major factor in development of aggressive behavior); Sabrina Weber et al., *Structural Brain Abnormalities in Psychopaths—A Review*, 26 BEHAV. SCI. & L. 7, 13 (2008) (stating that many studies have linked frontal lobe damage to aggressive behavior).

53. *See* Adrian Raine, *From Genes to Brain to Antisocial Behavior*, 17 CURRENT DIRECTIONS IN PSYCHOL. SCI. 323, 324 (2008). We can analogize to water pipes in order to better conceptualize the differences between structural and functional brain abnormalities. Structural abnormalities in the brain are like dents, holes, or even rust on a pipe. Conversely, functional abnormalities can be analogized to the amount of water flowing through the pipe, such as lower-than-normal levels of water flowing through the pipe. Nothing is structurally wrong with the pipe, but functionally, the flow of water may be decreased because of lower water pressure.

54. AM. PSYCHIATRIC ASS'N, DIAGNOSTIC AND STATISTICAL MANUAL OF MENTAL DISORDERS 701–02 (4th ed., text rev. 2000) [hereinafter DSM IV-TR]. Other signs and symptoms include failure to conform to social norms, reckless disregard for the safety of self or others, and consistent irresponsibility. *Id.*

55. For an extensive discussion about the prefrontal cortex as well as its associated behavioral changes, see Andrea L. Glenn, Yaling Yang & Adrian Raine, *Neuroimaging in Psychopathy and Antisocial Personality Disorder: Functional Significance and a Neurodevelopmental Hypothesis*, *in* NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM 81 (Joseph R. Simpson ed., 2012).

56. E. K. Miller & J. D. Wallis, *Executive Function and Higher-Order Cognition: Definition and Neural Substrates*, 4 ENCYCLOPEDIA NEUROSCIENCE 99, 99 (2009) ("It is needed to overcome local

to plan, to make judgments and decisions, and to regulate behavior.[57] Thus, disruption in the prefrontal cortex has been consistently implicated in problems with moral decisionmaking, processing reward and punishment information, inhibiting responses, exhibiting proper social conduct, and processing social and emotional information.[58] These are some of the symptoms that are also associated with antisocial personality disorder and with psychopathy. Therefore, evidence showing that a defendant has a brain abnormality in the prefrontal cortex may show that the defendant suffers from one of these disorders, and thus may serve as a mitigating factor during the sentencing phase. A typical argument using this sort of evidence would be that the defendant is less culpable because of a brain abnormality that predisposes him to such impairments in behavior. Since the defendant has less control over his behavior and is more susceptible than a normal person to violence, the defendant should receive a less severe punishment.

Both structural and functional abnormalities in the prefrontal cortex are known to disrupt executive functions and to lead to behavioral changes associated with antisocial personality disorder and psychopathy. Structural damage to the prefrontal cortex results in aberrant behavior like impulsivity, irritability, and an inability to empathize.[59] One study shows that individuals with antisocial personality disorder have an 11 percent reduction in gray matter volume in comparison to normal controls.[60] Another study shows that repeat violent offenders also have reduced gray matter in the prefrontal cortex.[61]

Functional abnormalities in the prefrontal cortex have also been implicated in such aberrant behavior. Impulsive, aggressive individuals have shown reduced

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considerations, plan and orchestrate complex sequences of behavior, and prioritize goals and subgoals.").

57. Rebecca Elliott, *Executive Functions and Their Disorders*, 65 BRIT. MED. BULL. 49, 50 (2003); Jessie A. Seiden, *The Criminal Brain: Frontal Lobe Dysfunction Evidence in Capital Proceedings*, 18 CAP. DEF. J. 395, 398 (2004).

58. Glenn, Yang & Raine, *supra* note 55, at 85.

59. *See, e.g.*, Harald Dressing, Alexander Sartorius & Andreas Meyer-Lindenberg, *Implications of fMRI and Genetics for the Law and the Routine Practice of Forensic Psychiatry*, 14 NEUROCASE 7, 8 (2008); Seiden, *supra* note 57, at 400. The most famous example of structural damage to the prefrontal cortex is the case of Phineas Gage. Gage was a railroad worker who was known to be hard working, well liked, and polite. However, Gage suffered an accident on the job whereby a three-and-a-half-foot long iron packed with gunpowder blasted through the side of his face and destroyed an area in his prefrontal cortex. Although Gage survived, he had severe personality changes including impulsiveness, an inability to make moral decisions, and an inability to engage in goal-directed behavior. *See* Batts, *supra* note 22, at 266–67.

60. Adrian Raine et al., *Reduced Prefrontal Gray Matter Volume and Reduced Autonomic Activity in Antisocial Personality Disorder*, 57 ARCHIVE GEN. PSYCHIATRY 119, 125 (2000); *see also* Rosen, *supra* note 17.

61. Jari Tiihonen et al., *Brain Anatomy of Persistent Violent Offenders: More Rather Than Less*, 163 PSYCHIATRY RES.: NEUROIMAGING 201, 206 (2008).

frontal lobe functioning compared to controls.[62] Such reduced frontal functioning has also been observed in murderers.[63] Moreover, violent offenders who are nonpsychotic also show reduced blood flow in the prefrontal cortex.[64]

2. Amygdala

The amygdala is another area in the brain that has been implicated in aberrant behavior, including aggression.[65] This area in the brain processes social emotions (such as fear, guilt, and arrogance) and is important in making moral judgments.[66] Proper functioning of the amygdala helps individuals learn to associate harmful actions with the pain and the distress of others, and thus facilitates development of empathy and discourages antisocial actions.[67] Research indicates that disruption of the amygdala, however, may result in emotional deficits, such as lack of remorse, as well as social dysfunctions, such as pathological lying.[68] Thus, individuals with abnormalities in the amygdala may be more prone to psychopathic tendencies as well as to antisocial, aggressive behavior. Like abnormalities in the prefrontal cortex, abnormalities in the amygdala may also serve as a mitigating factor during the sentencing phase.

Neuroscience research has linked both structural and functional abnormalities in the amygdala to behavioral changes. With respect to structural abnormalities, a study has shown that psychopathic individuals are more likely to have reduced volume in this area of the brain compared to normal controls.[69] Adolescents diagnosed with conduct disorder, which is charac-

62. *See* Antonia S. New et al., *Blunted Prefrontal Cortical 18Fluorodeoxyglucose Position Emission Tomography Response to Meta-Chlorophenylpiperazine in Impulsive Aggression*, 59 ARCHIVE GEN. PSYCHIATRY 621, 628 (2002).
63. *See* Adrian Raine et al., *Brain Abnormalities in Murderers Indicated by Positron Emission Tomography*, 42 BIOLOGICAL PSYCHIATRY 495, 502 (1997). PET scans of convicted murders show reduced glucose metabolism compared to controls. *Id.*
64. Henrik Soderstrom et al., *Reduced Regional Cerebral Blood Flow in Non-Psychotic Violent Offenders*, 98 PSYCHIATRY RES.: NEUROIMAGING 29, 40 (2000).
65. Batts, *supra* note 22, at 268.
66. Glenn, Yang & Raine, *supra* note 55, at 86–87; T. F. Heatherton & A. C. Krendl, *Social Emotion: Neuroimaging*, 9 ENCYCLOPEDIA NEUROSCIENCE 35, 37 (2009).
67. Glenn, Yang & Raine, *supra* note 55, at 86.
68. *Id.*
69. Yaling Yang et al., *Localization of Deformations Within the Amygdala in Individuals With Psychopathy*, 66 ARCHIVE GEN. PSYCHIATRY 986, 990 (2009). Some studies contest whether psychopaths have overt structural abnormalities compared to controls. *See* Kent A. Kiehl et al., *Limbic Abnormalities in Affective Processing by Criminal Psychopaths as Revealed by Functional Magnetic Resonance Imaging*, 50 BIOLOGICAL PSYCHIATRY 677, 682 (2001) (noting that magnetic resonance imaging (MRI) scans of the psychopathic individuals in the study did not show any structural brain abnormalities, but also stating that there may be a possibility that these individuals have subtle abnormalities).

terized by aggressive and antisocial behavior,[70] also show a reduction of amygdala volume.[71]

Studies likewise link functional abnormalities in the amygdala with such aberrant behavior. Research has shown abnormal amygdala activation in murderers.[72] Generally, individuals with higher scores on a diagnostic test for psychopathy (meaning they have psychopathic tendencies) show less amygdala activation compared to normal controls.[73] One study shows that diagnosed psychopaths have lower amygdala activation levels when processing affective stimuli.[74] Thus, lower activation in the amygdala may result in difficulty processing abstract affective material, including complex social emotions like love, empathy, and guilt.[75]

Unlike psychopathic individuals, individuals with intermittent explosive disorder (IED), which is characterized by impulsive, affective-driven aggressive behavior, exhibit greater amygdala activation.[76] A study of individuals with IED observed that these individuals exhibit greater activation in the amygdala in response to stimuli showing angry faces.[77] Their increased amygdala activation may result in reactive emotional responses even to minor, external stimuli, which then may result in aggressive, impulsive behavioral responses.

These studies are just a small sample of the body of research linking brain abnormalities to aberrant behavior. However, by touching on some of the studies in the neuroscience literature, this Subpart shows that there is empirical evidence of both structural and functional brain abnormalities that disrupt normal behavior.

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70. DSM IV-TR, *supra* note 54, 93–94.
71. Philipp Sterzer et al., *A Structural Neural Deficit in Adolescents With Conduct Disorder and Its Association With Lack of Empathy*, 37 NEUROIMAGE 335, 340 (2007).
72. Raine et al., *supra* note 63, at 502.
73. One study used the Prisoner's Dilemma game as a behavioral task. The task was manipulated such that when the participant cooperated, the computer did not reciprocate the participant's cooperation. Individuals with psychopathic tendencies exhibited less amygdala activation compared to controls when participating in the game. James K. Rilling et al., *Neural Correlates of Social Cooperation and Non-Cooperation as a Function of Psychopathy*, 61 BIOLOGICAL PSYCHIATRY 1260, 1270 (2007).
74. *See* Kiehl, *supra* note 69, at 681.
75. *See id.* at 677.
76. DSM IV-TR, *supra* note 54, at 663–64.
77. Emil F. Coccaro et al., *Amygdala and Orbitofrontal Reactivity to Social Threat in Individuals With Impulsive Aggression*, 62 BIOLOGICAL PSYCHIATRY 168, 172 (2007).

II. THE CONVENTIONAL WISDOM ABOUT THE IMPACT OF NEUROSCIENCE EVIDENCE: A FOCUS ON THE VISUAL IMPACT OF THE NEUROIMAGES

There appears to be good reason why many legal commentators are concerned about neuroscience evidence. General neuroscience evidence, meaning neuroscience evidence without an actual neuroimage, significantly affects laypeople's judgments. A study by Deena S. Weisberg et al. found that laypeople believe that explanations of a psychological phenomenon with logically irrelevant neuroscience information are better than explanations without such information.[78] What was more shocking were judgments about bad explanations. When general neuroscience information was added to bad explanations, laypeople judged them to be more satisfying than they actually were.[79] The authors suggested that laypeople appear to have an affinity for reductionistic explanations of cognitive phenomena.[80] Thus, laypeople seem to find that a lower-level explanation rooted in neuroscience best explains a higher-level psychological phenomenon.[81]

A similar effect appears to occur in the courtroom.[82] Jariel A. Rendell et al. performed a study evaluating how general neuroscience evidence affects verdicts of NGRI in mock jury trials.[83] The authors found that the defendant was significantly more likely to receive a verdict of NGRI when an expert witness presented neuroscience evidence.[84] Mock jurors perceived neuroscience evidence as more

78. Deena S. Weisberg et al., *The Seductive Allure of Neuroscience Explanations*, 20 J. COGNITIVE NEUROSCIENCE 470, 475 (2008).

79. *Id.*

80. *See id.* at 476. Reductionism seeks "to locate causes internal to systems and to identify the causal powers of macroscopic phenomena with their molecular constituents." J.D. Trout, *Seduction Without Cause: Uncovering Explanatory Neurophilia*, 12 TRENDS COGNITIVE SCI. 281, 282 (2008). This theory works to make complicated problems cognitively manageable by focusing on a limited number of local, causal factors. *Id.*

81. *See id.*

82. I would like to note that some of the empirical studies discussed in this paper involve mock jurors' judgments during the guilt-innocence phase. These studies are included even though this Comment focuses on the sentencing phase because of the limited number of mock jury studies regarding perceptions of neuroscience evidence. Although the criteria for admission of evidence and judgments during the guilt-innocence phase are different, there is a higher bar to pass in order to admit evidence and render, for example, a verdict of not guilty by reason of insanity (NGRI) compared to that of the sentencing phase. A fortiori, such results can be extrapolated to this Comment's discussion of sentencing decisions.

83. Jariel A. Rendell et al., *Expert Testimony and the Effects of a Biological Approach, Psychopathy, and Juror Attitudes in Cases of Insanity*, 28 BEHAV. SCI. & L. 411 (2009).

84. *Id.* at 421. The authors refer to the neuroscience experimental condition as "biological." *Id.* at 417. However, the "biological evidence" was based on neurochemical imbalances and hypofrontality in

persuasive than psychological evidence and this perception correlated with lower conviction rates.[85] Again, laypeople appear to be swayed by a reductionistic neuroscience explanation when it explains a higher-level behavioral abnormality like a mental disorder. This influence on perception significantly changes outcomes of trials.[86] Thus, assessing the "seductive allure" of neuroscience evidence becomes imperative because such evidence has practical implications in the courtroom.

A. How Does the Conventional Wisdom Explain the Impact of General Neuroscience Evidence?

The imperative nature of assessing such evidence has not gone unnoticed by the legal community. The Weisberg et al. and Rendell et al. studies coupled with the neuroscience research linking aberrant behavior to brain abnormalities have sparked great interest in the legal community about the impact of neuroscience evidence in the courtroom. Between 2000 and 2009, the number of law review articles regarding neuroscience increased fourfold.[87] Moreover, in 2009 alone, there were more than two hundred law review articles published referring to neuroscience.[88] Based on the sheer number of articles published, it is safe to say that the legal community is very interested in the influence of neuroscience on the law and particularly in the courtroom.[89]

With great interest comes great concern about introducing such evidence in the courtroom. The conventional wisdom presumes that neuroimages themselves, rather than the accompanying expert testimony, cause much of the broad impact of general neuroscience evidence discussed above.[90] Thus, the conventional wisdom is that the visual impact of neuroimages drives the overpersuasiveness of

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the defendant's brain, which are more specifically, neuroscience evidence. *Id.* This Comment therefore uses "neuroscience" rather than "biological" evidence.

85. *Id.* at 422. The authors inferred that the mock jurors weighed the responsibility of mental illness against the responsibility of the defendant because even though there were significantly lower conviction rates due to NGRI verdict, the defendant's guilt and responsibility ratings remained consistent. *Id.*

86. *See id.*

87. Owen D. Jones & Francis X. Shen, *Law and Neuroscience in the United States*, *in* INTERNATIONAL NEUROLAW: A COMPARATIVE ANALYSIS 349, 351 (Tade Matthias Spranger ed., 2012).

88. *Id.*

89. *See id.*

90. For an extensive discussion about the impact of neuroimages, see Brown & Murphy, *supra* note 22, at 1188–95.

neuroscience evidence and that neuroimages both unduly sway jurors and lack probative value in and of themselves.[91]

This conventional wisdom is based on the following theories concerning the visual features of neuroimages: the Christmas tree phenomenon, conflation with photographs, the status as a scientific image, and reductionism. What is commonly referred to as the "Christmas tree" phenomenon[92] posits that multicolored, bright lights in fMRI and PET scans dazzle jurors and cause them to pay insufficient attention to the expert testimony interpreting the neuroimages.[93] These functional neuroimaging scans are especially targeted because their colorful, visual impact is considered to be more dramatic than black-and-white structural neuroimaging scans.[94] This is problematic, however, because dramatic contrasts in color do not necessarily correlate with significant differences and may instead reflect minor differences in brain activity levels.[95]

The theory that jurors perceive neuroimages as equivalent to photographs of the brain also supports the conventional wisdom.[96] Neuroimages purportedly validate what jurors expect brains to look like because laypeople are consistently exposed to them in the popular media.[97] Thus, neuroimages make jurors feel as if they can see directly into the defendant's brain.[98] Since jurors believe that they can actually see in a neuroimage what they perceive to be the source of abnormal behavior, the theory suggests that jurors will be substantially more persuaded by neuroimages than by traditional forms of testimony, such as behavioral descrip-

91. *See, e.g.*, Joseph Dumit, *Objective Brains, Prejudicial Images*, 12 SCI. CONTEXT 173, 187 (1990) (stating that PET scans are extremely prejudicial because of their visual impact).

92. Feigenson, *supra* note 14, at 245; Dean Mobbs et al., *Law, Responsibility, and the Brain*, 5 PLOS BIOLOGY 693, 699 (2007).

93. Brown & Murphy, *supra* note 22, at 1190; Feigenson, *supra* note 14, at 246.

94. *See* Compton, *supra* note 18, at 345. For example, fMRI scans result in a three-dimensional reconstruction of the brain with color mapping of its function, whereas MRI scans produce black-and-white, two-dimensional images of the brain. *Id.*

95. Appelbaum, *supra* note 23, at 22. The activity in the abnormal brain and that in a normal brain might be similar, but the normal brain can appear significantly more or less active than the abnormal brain because of a lower bar for statistical significance. *Id.*; Brown & Murphy, *supra* note 22, at 1153; Feigenson, *supra* note 14, at 240.

96. *See* Brown & Murphy, *supra* note 22, at 1191; Feigenson, *supra* note 14, at 246; Adina L. Roskies, *Neuroimaging and Inferential Distance*, 1 NEUROETHICS 19, 21 (2008).

97. *See* Regula Valérie Burri & Joseph Dumit, *Social Studies of Scientific Imaging and Visualization*, *in* THE HANDBOOK OF SCIENCE AND TECHNOLOGY STUDIES 297, 297 (Edward J. Hackett et al. eds., 3d ed. 2007); Feigenson, *supra* note 14, at 247 ("[People] have seen brain images in magazines, on television and on the Internet . . . . [T]hese images have been assimilated . . . to a familiar medium (photography) which people are already habituated to see through directly onto reality."); *see also* Diane M. Beck, *The Appeal of the Brain in the Popular Press*, 5 PERSP. ON PSYCHOL. SCI. 762, 762 (2010) (stating that there is a "healthy proportion" of news articles about neuroscience research in the popular press).

98. Feigenson, *supra* note 14, at 247.

tions by psychology and psychiatry expert witnesses.[99] Yet, neuroimages cannot be thought of as photographs of the brain. Functional neuroimaging scans are unlike photographs because neural activity has no actual visual properties.[100] Structural neuroimaging scans are also unlike photographs because the imaging parameters are nonstandardized and can be technically manipulated from scan to scan.[101] For example, the pulse sequencing parameters like the echo time and the repetition time can be changed to manipulate the contrast on an MRI scan.[102] Also, depending on other parameters such as the voxel size[103] and the data reconstruction algorithm,[104] the spatial resolution can change, which means that one structural neuroimaging scan can look extremely different from another scan of the exact same brain.[105]

The conventional wisdom is also strengthened by the fact that neuroimages have acquired the status of a prototypical scientific image.[106] This status leads jurors to view neuroimages as "objective authority of science and technology"[107] because they are mechanized and computerized.[108] Since jurors perceive neuroimages as

99. Brown & Murphy, *supra* note 22, at 1193; Dumit, *supra* note 91, at 184 (stating that neuroimaging appears to not only take over seeing, but also judging); Neal Feigenson & Richard K. Sherwin, *Thinking Beyond the Shown: Implicit Inferences in Evidence and Argument*, 6 LAW PROBABILITY & RISK 295, 299 (2007); Schweitzer & Saks, *supra* note 27, at 594.

100. Roskies, *supra* note 96, at 29. Functional neuroimages are translations of the nonvisual neural activity and thus create an illusion of inferential proximity. *Id.* at 29–30; *see also* Logothetis, *supra* note 3, at 869 (stating that fMRI images measure correlate neural activity, not actual neural activity). These neuroimages measure the relative, not absolute, brain activity and there is no real baseline measure because the control fMRI scans pool the norm. *See* Feigenson, *supra* note 14, at 240 (noting that differences in brain activation in fMRI scans between abnormal and control states are "obtained by subtracting the [blood oxygenation level-dependent (BOLD)] signal of one from the other").

101. Jennifer Kulynych, *Brain, Mind, and Criminal Behavior: Neuroimages as Scientific Evidence*, 36 JURIMETRICS J. 235, 238 (1996) [hereinafter Kulynych, *Brain*]; *see also* Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 22, at 1254 ("Although neuroimages may resemble photographs of the brain, neuroimaging technology is very different from visible light photography. Neuroimages are digital images . . . [which are] computer-generated visual representation[s] of numerical measurements . . . . [A] neuroimage is far more similar to a chart or a line graph than to a photograph developed from a negative.").

102. The echo time is the time between the first radiofrequency (electromagnetic) pulse and the peak of the detected signal. The repetition time is the time between each radiofrequency pulse in a series. *See* Edward F. Jackson et al., *A Review of MRI Pulse Sequences and Techniques in Neuroimaging*, 47 SURGICAL NEUROLOGY 185, 186 (1997).

103. Voxel size is a volume unit that represents three-dimensional resolution. The higher the spatial resolution is, the smaller the voxel size is. Johan de Jong & Marjolijn Guerand, *Application Tips: Voxel Size, Bandwidth, and Water-Fat Shift*, 36 FIELD STRENGTH 22, 22 (2008).

104. Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 22, at 1254–55.

105. *Id.*

106. Feigenson, *supra* note 14, at 247.

107. Burri & Dumit, *supra* note 97, at 299.

108. Feigenson, *supra* note 14, at 247.

objective, they are allegedly susceptible to "neurorealism," or using neuroimages to make a subjective phenomenon like a behavioral abnormality appear objective and real.[109] Thus, presenting neuroimages to explain a behavioral abnormality will be viewed as more credible because they are seen as objective.[110] This potential perception by jurors is troublesome, however, because the production and the interpretation of these neuroimages are very subjective.[111] Moreover, neuroimages are increasingly used in the popular media to create dramatic headlines and to legitimize tenuous applications of neuroscience.[112] Therefore, neuroimages may not be as objective as laypeople perceive them to be.

Lastly, the idea of reductionism, which proposes that laypeople possess a natural affinity for explanations of cognitive phenomena based on physiological representations, supports the conventional wisdom.[113] Reductionism also posits that physical representations of cognitive phenomena—like neuroimages—are perceived to be more satisfying and credible than abstract representations like verbal expert testimony about a psychological construct of interest.[114] Thus, the neuroimage is claimed to be persuasive because it works to make the psychological construct of interest more concrete by (1) locating the psychological construct in a specific area in the person's brain and (2) providing a foundation in visible reality.[115] Yet, higher-level brain functions, like cognition and emotion, cannot be reduced to one region in the brain because it is highly likely that neural correlates are distributed among many regions of the brain.[116]

All of these theories about the various visual features of neuroimages support the conventional wisdom that neuroimages are prejudicial and lack probative value in and of themselves because of the overpersuasiveness of their visual impact. However, much of the discussion above about the conventional wisdom is based on theory, not empirical studies. Although Weisberg et al. and Rendell et

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109. Cliodhna O'Connor et al., *Neuroscience in the Public Sphere*, 74 NEURON 220, 220 (2012).
110. *Cf.* Feigenson, *supra* note 14, at 247 (discussing the persuasive force of functional neuroimages by highlighting "their status as prototypical scientific images").
111. *See* Brown & Murphy, *supra* note 22, at 1169–71; *see also* Feigenson, *supra* note 14, at 240 ("fMRI data are thresholded for display at an arbitrary level of significance (often but not always p < .05). The lower the bar for statistical significance of reported differences in brain activity between baseline and experimental conditions, the more 'active' regions appear and the more widely distributed in the brain they appear to be." (emphasis omitted) (citation omitted)).
112. O'Connor et al., *supra* note 109, at 224–25.
113. Weisberg et al., *supra* note 78, at 476.
114. David P. McCabe & Alan D. Castel, *Seeing is Believing: The Effect of Brain Images on Judgments of Scientific Reasoning*, 107 COGNITION 343, 344 (2008).
115. Feigenson, *supra* note 11, at 247–48. Even if there are only subtle brain abnormalities, this theory alleges that jurors may believe that there are real differences psychologically, and more importantly, legally. *Id.*; Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 19, at 1259.
116. Appelbaum, *supra* note 23, at 22.

al. performed empirical studies, their purpose was to determine whether general neuroscience evidence affected laypeople's judgments. They did not seek to tease out what specifically about neuroscience evidence caused overpersuasiveness and thus they did not test the implications of neuroimages.

Therefore, supporters of the conventional wisdom focus on three additional empirical studies that measure the effect of neuroimages on people's perceptions and show that the visual impact of neuroimages is overpersuasive.[117] The first study, by David P. McCabe and Alan D. Castel, tested the effect of neuroimages on judgments about cognitive neuroscience data.[118] The authors found that when an fMRI scan was presented along with an article explaining the data, the article was given a significantly higher rating of scientific reasoning than, for example, the same article with just a bar graph.[119] The authors concluded that the credibility of the neuroimage lies in the actual image itself.[120] Thus, neuroimages hold a "seductive allure" over the minds of laypersons by validating even irrelevant scientific findings.[121] This specific finding by McCabe and Castel supports the theory that neuroimages have acquired the status of an objective, scientific image. Moreover, because this experiment used fMRI scans, this study also corroborates the theory that jurors are very likely to be susceptible to the bright lights in neuroimages.

Jessica R. Gurley and David K. Marcus saw a similar effect in their experiment examining the impact of MRI scans on mock jurors' decision about the NGRI defense.[122] The addition of the neuroimage significantly increased the

117. Articles frequently cite to David P. McCabe and Alan D. Castel to substantiate fear about the conventional wisdom regarding neuroimages' overpersuasiveness. *See, e.g.*, Brown & Murphy, *supra* note 22, at 1201–02; Martha J. Farah & Cayce J. Hook, *The Seductive Allure of "Seductive Allure*,*"* 8 PERSP. ON PSYCHOL. SCI. 88 (2013); Thomas Nadelhoffer & Walter Sinnott-Armstrong, *Neurolaw and Neuroprediction: Potential Promises and Perils*, 7 PHIL. COMPASS 631, 638 (2012); Walter Sinnott-Armstrong et al., *Brain Images as Legal Evidence*, 53 EPISTEME 359, 369 (2008). They also cite to Gurley and Marcus. *See, e.g.*, Batts, *supra* note 22, at 270; Judith G. Edersheim et al., *Neuroimaging, Diminished Capacity and Mitigation*, *in* NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM 163, 176 n.102 (Joseph R. Simpson ed., 2012); Nadelhoffer & Sinnott-Armstrong, *supra*, at 638; Rendell, *supra* note 83, at 414.

118. McCabe & Castel, *supra* note 114, at 345.

119. *Id.* at 349. It is interesting to note that this significant effect still remained when the authors conducted a new experiment in which the article actually questioned the ability of the neuroimage to validly address the cognitive neuroscience data. Schweitzer & Saks, *supra* note 99, at 596.

120. McCabe & Castel, *supra* note 114, at 350.

121. *Id.*; *see also* Schweitzer & Saks, *supra* note 27, at 596 ("[T]hese findings suggest the possibility that, in the courtroom, the use of neuroimages could cloud jurors' judgments of expert evidence, and could enhance the persuasiveness of bad science.").

122. In one of the experimental conditions, the authors used an MRI scan showing extensive damage to the prefrontal cortex along with expert testimony explaining that there was reduced volume in the

likelihood that jurors would render a NGRI verdict.[123] The authors suggested that this occurs because a neuroimage provides mock jurors with tangible, concrete evidence of a biological abnormality in the brain.[124] Therefore, this study is frequently used to validate the reductionism theory because of the inference that a biological abnormality in the brain worked to make the psychological construct of interest more concrete. Furthermore, the authors' conclusion also supports the theory that neuroimages are conflated with photographs because jurors feel as if they are actually seeing the brain abnormality.

In addition to these two frequently cited studies, the Madeleine Keehner et al. study also supports the conventional wisdom, but is rarely cited by legal scholarship.[125] This study compared different functional neuroimage formats and found that laypeople viewed the highly realistic, three-dimensional brain images as significantly more credible than the two-dimensional brain images.[126] The authors of this study suggest that laypeople consider three-dimensional functional neuroimages as credible because such neuroimages are likely to be viewed as photographs of the brain.[127]

III. PROBLEMS WITH THE CONVENTIONAL WISDOM

However, evidence regarding whether neuroimages influence laypeople's perception is actually mixed. A study by David Gruber and Jacob A. Dickerson found the exact opposite result of the McCabe and Castel study.[128] Gruber and

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area. *See* Jessica R. Gurley & David K. Marcus, *The Effects of Neuroimaging and Brain Injury on Insanity Defenses*, 26 BEHAV. SCI. & L. 85, 89–90 (2008).

123. *Id.* at 93.

124. *Id.* at 94 (comparing neuroimages as more tangible than other traditional types of evidence that is typically presented in psychological and psychiatric testimony).

125. Madeleine Keehner et al., *Different Clues From Different Views: The Role of Image Format in Public Perceptions of Neuroimaging Results*, 18 PSYCHONOMIC BULL. & REV. 422, 426–27 (2011). Recently, a Japanese study by Kenji Ikeda et al. demonstrated that functional neuroimages affect credibility judgments. Kenji Ikeda et al., *Neuroscientific Information Bias in Metacomprehension: The Effect of Brain Images on Metacomprehension Judgment of Neuroscience Research*, 20 PSYCHONOMIC BULL. & REV. 1357, 1362 (2013). This study used a whole brain functional neuroimage like the one used in the Keehner et al. study. *Compare* Keehner et al., *supra*, at 425 fig.2 (showing a whole brain functional neuroimage on the top), *with* Ikeda et al., *supra*, at 1359 fig.1a (showing a whole brain functional neuroimage). Laypeople were significantly more likely to perceive a text passage with a functional neuroimage as more credible than the same text passage with just a bar graph. *Id.* at 1362.

126. Keehner, *supra* note 125, at 423–24.

127. *Id.*

128. *See* David Gruber & Jacob A. Dickerson, *Persuasive Images in Popular Science: Testing Judgments of Scientific Reasoning and Credibility*, 21 PUB. UNDERSTANDING SCI. 938 (2012). There are also other methodological problems with the McCabe and Castel study, which is worrisome because the conventional wisdom relies heavily on it. The most significant problem is that it used a within-

Dickerson used a similar experimental design,[129] but did not find that subjects viewed explanations with fMRI images as more credible or reasonable than other explanations without fMRI images.[130] Moreover, they found that no images of any sort seemed to influence the subjects' evaluations of the article.[131]

Recently, there have been attempts to repeat the experiments in the McCabe and Castel study. Robert B. Michael et al. ran ten replications of the McCabe and Castel study and combined their data with the original data (from McCabe and Castel) in a meta-analysis.[132] Unlike the McCabe and Castel finding, however, this meta-analysis showed that the fMRI image exerted little to no influence on credibility judgments compared to the no-fMRI-image condition.[133] Cayce J. Hook and Martha J. Farah also attempted to conceptually replicate the McCabe and Castel study by examining whether the addition of an fMRI image affected laypeople's overall evaluation of fictional research descriptions.[134] Hook and Farah failed to replicate the McCabe and Castel results.[135] That is, laypeople did not view the research in question as more credible when it was accompanied by an fMRI image than when it was accompanied by a bar graph or a stock photograph.[136] Lastly, N.J. Schweitzer et al. directly replicated the McCabe and Castel study.[137] However, the authors did not find that laypeople are more likely to perceive an article with an fMRI image as more credible compared to an article with a bar graph or even an article without any images.[138]

Schweitzer et al. also attempted to conceptually replicate the Keehner et al. study to test whether the type of fMRI image matters. The authors hypothesized based on the Keehner et al. study that a highly realistic, three-dimensional fMRI

subjects design, meaning that each subject compared an article with and without the functional neuroimage, which may introduce potential confounding variables. *See* N. J. Schweitzer et al., *Neuroimages as Evidence in a Mens Rea Defense*, 17 PSYCHOL. PUB. POL'Y & L. 357, 361 (2011).

129. Gruber and Dickerson placed different images, including an fMRI scan, above a popular neuroscience article in order to evaluate whether fMRI scans have an undue influence on people's perceptions. Gruber & Dickerson, *supra* note 128, at 942. The other experimental conditions included no image, an artistic image of the brain, and an image of the brain from the film *Minority Report*. *Id.*

130. *Id.* at 944.

131. *Id.*

132. Michael et al., *supra* note 27, at 721 (attempting to replicate experiment 3 in the McCabe and Castel study which produced the largest effect and used a between-subjects design).

133. *Id.* at 723.

134. Hook & Farah, *supra* note 27, at 1398.

135. *Id.* at 1404.

136. *Id.*

137. Schweitzer et al., *supra* note 27, at 506. Other recent research on neuroimage bias finds no evidence of a biasing influence. *See id.* at 508–09.

138. *Id.* at 506.

image of a brain may produce effects on laypeople's judgments.[139] Schweitzer et al. were able to repeat the findings but only in the context of a within-subjects design.[140] That is, laypeople only viewed the text passage with the fMRI image as more credible if they compared the same text passage without the fMRI image.[141] If the laypeople did not compare the text passage with and without the fMRI image, they were not more likely to perceive the text passage with an fMRI image, even one that is highly realistic and three-dimensional, as more credible compared to the same passage without any image.[142]

What about in the context of a courtroom? N.J. Schweitzer and Michael J. Saks looked at whether MRI scans affected mock jurors' decision about the NGRI defense.[143] The neuroimage experimental condition showed an MRI of the defendant's brain with physical damage to a large area of the frontal lobe.[144] The authors concluded that the neuroimage condition itself had no independent effect.[145] Neuroscience-based conditions that did not use a neuroimage were just as persuasive.[146] In fact, all neuroscience-based conditions, regardless of whether there was a neuroimage or not, increased the mock jurors' willingness to find a defendant NGRI.[147]

139. *Id.*
140. *Id.* at 509.
141. *Id.*
142. *Id.* at 507.
143. *See* Schweitzer & Saks, *supra* note 27, at 592. Unlike Gurley and Marcus, Schweitzer and Saks examined the effects of the MRI scan and the expert testimony separately. *Id.* at 598. The neuroimage condition was presented using both the expert testimony explaining the neuroimage and the neuroimage itself, whereas the "neuro-no-image" condition was presented with the same expert testimony, but without the neuroimage. *Id.* at 589–99. In contrast, Gurley and Marcus presented both the MRI scan and expert testimony together in their neuroimaging condition and did not have a separate condition isolating the two. *See* Gurley & Marcus, *supra* note 122, at 89–90. This results in confounding variables because it is uncertain whether the image, the testimony, or the combination of the two affected the mock jurors' perceptions. *See* Hook & Farah, *supra* note 27, at 1398 (suggesting that the testimony may have been the influential factor rather than the MRI scan).
144. Schweitzer & Saks, *supra* note 27, at 598. The expert testimony experimental condition informed the mock juror that there was physical damage to a large area of the frontal lobe, but did not show the image. *Id.*
145. *Id.* at 603. fMRI scans showing abnormal brain activity have also been found to produce insignificant effects independently in a mock-jury study. So Yeon Choe, Perceptions About Culpability, Free Will, and Punishment and How They Change With Neuroscience Explanations 43 (Apr. 2011) (unpublished manuscript) (on file with author) (noting that there was no additive effect when either CT scans or fMRI scans accompanied their respective descriptions of the medical diagnosis).
146. Schweitzer & Saks, *supra* note 27, at 603.
147. Neuroscience-based evidence was more persuasive than the other conditions: psychological evidence, anecdotal family history evidence, and no evidence. *Id.*

A recent study by Michael J. Saks et al. specifically examined the impact of functional abnormalities during the sentencing phase of capital trials.[148] The authors asked mock jurors to give verdicts (either death or life in prison) to a defendant who was diagnosed with either psychopathy or schizophrenia.[149] The fMRI image condition did not significantly affect mock jurors' judgments about punishment decisions.[150] That is, the fMRI image condition did not reduce or increase the likelihood of subjects rendering a death sentence compared to the non-fMRI image conditions.[151] The authors found, however, that a functional brain abnormality (without the fMRI image) significantly affected capital sentencing decisions for a defendant diagnosed with schizophrenia compared to a defendant without any disorder.[152] Curiously, the same functional brain abnormality did not affect capital sentencing decisions for a defendant diagnosed with psychopathy compared to a defendant without any disorder.[153]

Contrary to conventional wisdom, these studies indicate that the visual impact of the neuroimage may not hold special power over the minds of laypeople.[154] In the experiments discussed above, neuroimages do not distort laypeople's judgments about scientific reasoning, credibility, or validity,[155] nor do they unduly in-

148. Michael J. Saks et al., *The Impact of Neuroimages in the Sentencing Phase of Capital Trials*, J. EMPIRICAL LEGAL STUD. 1, 10 (forthcoming 2014).

149. *Id.* The authors also asked subjects to rate whether they perceived the defendant to be dangerous, responsible for his actions, and amenable to treatment. *Id.*

150. Saks et al. note that for a defendant diagnosed with psychopathy, the fMRI image condition marginally decreased death sentences compared to the non-fMRI image condition. *Id.* at 13. For a defendant diagnosed with schizophrenia, the fMRI image condition marginally increased death sentences compared to the non-fMRI image condition. *Id.* However, these are just trends and are not statistically significant. *See id.* n.17, n.20 (stating the p-value = 0.12 for psychopathic defendants and the p-value = 0.33 for schizophrenic defendants, which is greater than the generally accepted value for statistical significance (p = 0.05)).

151. *Id.* at 13. The fMRI image condition did significantly affect some judgments. For a defendant diagnosed with psychopathy, the fMRI image condition significantly decreased judgments of responsibility compared to the non-fMRI conditions. For a defendant diagnosed with schizophrenia, the fMRI image condition significantly increased judgments of responsibility compared to the non-fMRI conditions. *Id.* When mock jurors were asked to render verdicts, however, judgments about the responsibility of the defendant for his actions did not translate into statistically significant changes in punishment decisions. *Id.* Also, there may be other confounding variables that are driving the result rather than the fMRI image itself. One such confounding variable may be laypeople's perceptions and biases toward the diagnosis itself (psychopathy and schizophrenia). *See id.* at 19.

152. *Id.* at 14 (noting that mock jurors were significantly less likely to give a death sentence verdict for a defendant diagnosed with schizophrenia compared to the control condition).

153. *Id.* at 13–14 (noting that there were no significant differences in sentencing decisions for a defendant diagnosed with psychopathy compared to the control condition).

154. *See* Gruber & Dickerson, *supra* note 128, at 944; Schweitzer & Saks, *supra* note 27, at 604.

155. *See* Gruber & Dickerson, *supra* note 128, at 944; Hook & Farah, *supra* note 27, at 1404; Michael et al., *supra* note 27, at 723; Schweitzer et al., *supra* note 27, at 506–07.

fluence jurors when jurors are considering sentencing decisions.[156] One reason for this disparity may be that laypeople are savvier than we think or have become savvier about neuroscience in recent years. However, in light of the Weisberg et al. and Rendell et al. studies about general neuroscience evidence, this is probably untrue. Moreover, Michael et al. successfully replicated the findings of Weisberg et al. five years later.[157] Another interpretation is that it is impossible to draw definite conclusions about the neuroimages' visual impact because there are only a few studies that reach inconsistent results. Though the studies reach inconsistent results, the studies that test for effects of general neuroscience evidence appear to suggest that such evidence influences jurors.[158] Thus, there may be some aspect of neuroscience evidence aside from the visual impact of neuroimages that consistently produces effects on laypeople's judgment.

IV. ARE WE MISDIAGNOSING THE PROBLEM?

After considering the full extent of empirical studies observing the impact of neuroimaging, the conventional wisdom may be erroneous. Although some empirical studies show that the visual impact of neuroimages may drive the overpersuasiveness of neuroscience evidence, other studies demonstrate that neuroimages have no independent effect on laypeople's judgments. Thus, the visual characteristics that are theorized to be prejudicial may not exert persuasive power over the minds of laypeople. Nevertheless, studies have consistently found that such general neuroscience evidence without neuroimages does impact laypeople's judgments. If it is not the visual nature of neuroimages, then what drives the overpersuasiveness of neuroscience evidence? This Comment proposes that the structure/function paradigm better explains the overpersuasiveness of neuroscience evidence. The structure/function paradigm tells a more consistent, compelling story about the impact of neuroscience evidence than does the conventional wisdom. The paradigm posits that laypeople perceive structural and functional abnormalities differently and hence, these causes do not have the same impact on judgments. As this Comment explains, the structure/function paradigm resolves the inconsistencies in the empirical

156. *See* Saks et al., *supra* note 148, at 13; Schweitzer & Saks, *supra* note 99, at 603–04.
157. Michael et al., *supra* note 27, at 724.
158. *See id.* (verifying the results of the Weisberg et al. study); Saks et al., *supra* note 148, at 14; Schweitzer & Saks, *supra* note 27, at 603 (noting that there is a persuasiveness in neuroscience expert evidence whether or not it is accompanied by a brain image); Weisberg et al., *supra* note 78, at 475 (noting that laypeople and even students in a cognitive neuroscience class found bad explanations with logically irrelevant neuroscience information as more satisfying than they actually were).

studies that the conventional wisdom fails to clarify. The paradigm also better explains the five cases that are overwhelmingly cited in the legal literature to support the conventional wisdom.

A. Why Are Structural Abnormalities More Causally Potent Than Functional Abnormalities?

Structural deficits are seen as more powerful explanations of a defendant's aberrant behavior than functional abnormalities. Laypeople are more satisfied when a structural deficit explains a behavioral abnormality because it is a more prominent, physical cause.[159] People are generally more attuned to physical aspects of reality.[160] We look at the world in terms of cause and effect and favor mechanistic, or physical, explanations for cause-effect relationships.[161] Thus, we perceive physical causes as more familiar, authoritative, and more likely to be accurate.[162] In light of our affinity for physical explanations, the structure/function paradigm posits that jurors possess a naïve theory that structural deficits are significantly more deleterious and proximal determinations of abnormal behavior than are functional abnormalities.

A structural deficit is also seen as more credible and reasonable because it is perceived as being stable over time such that it impacts a person's behavior across all situations and all time. A structural deficit has been shown to reduce sentencing decisions and to decrease mock jurors' perceptions of the defendant's culpa-

159. Functional abnormalities are also arguably a physical cause. However, the concept that a functional abnormality is a physical cause may be too subtle for laypeople, who are more apt to focus on prominent, tangible physical causes like brain lesions. *Cf.* Klaus Fiedler et al., *Great Oaks From Giant Acorns Grow: How Causal-Impact Judgments Depend on the Strength of the Cause*, 41 EUR. J. SOC. PSYCHOL. 162, 171–72 (2011) (noting that when the strength of the causal manipulation was salient enough, strong causes produced higher causality judgments compared to weak causes that produced equally strong effects, which may partly be an adaptive mechanism; that is, people tend to focus on visible causes since subtle causes are less likely to be detectable in a complex environment); Rumen I. Iliev et al., *Moral Kinematics: The Role of Physical Factors in Moral Judgments*, 40 MEMORY & COGNITION 1387, 1387 (2012) (observing that in an experiment looking at how dynamic states of objects and physical properties of the contact influence subsequent moral judgments, people are sensitive to magnitudes and frequencies of the motion (cause) and contact (effect)). Moreover, when functional neuroimaging evidence is presented, people are more likely to focus on the abnormal functioning of some area in the brain (such as low brain activity levels in the amygdala) rather than the physical cause of the abnormal functioning.

160. *See, e.g.*, Iliev, *supra* note 159, at 1387. As adults, we have already formed heuristics based on naïve physical theories about how the world works. Jordan R. Schoenherr et al., *What Makes an Explanation Believable?: Mechanistic and Anthropomorphic Explanations of Natural Phenomena*, 33 COGNITIVE SCI. SOC'Y 1425 (2011).

161. *See* Schoenherr et al., *supra* note 160.

162. *Id.*

bility and responsibility in a crime, regardless of the severity of the crime.[163] However, judgments about a defendant with functional abnormalities in the brain did not significantly differ from that of a defendant with no medical diagnosis.[164] Thus, laypeople may view structural deficits as highly stable, whereas they see much variability in brain activation levels.[165] Perception of stability matters because people are more likely to believe that such a brain abnormality actually affected behavior during the commission of the crime.[166]

Although mock jurors believe that a structural abnormality consistently affects behavior during all situations and all time, they also often believe that a defendant with a structural abnormality is less likely to reoffend compared to a defendant with a functional abnormality.[167] On the surface, this may seem inconsistent. It appears that laypeople perceive an organic, structural cause as being treatable as it is stable.[168] As of today, a tumor or lesion alleged to affect behavior can be surgically removed, whereas it is difficult, if not impossible, to treat functional abnormalities.[169] Thus, laypeople may place a greater emphasis on rehabilitation rather than retribution for defendants with structural abnormalities, which may affect sentencing decisions.[170]

More importantly, these perceptions about the stability and the treatability of structural brain abnormalities have practical implications and affect decisions about prison time. A defendant with a structural deficit will more likely receive a significantly lower prison sentence.[171] Mock jurors may believe that a defendant with a structural brain abnormality has less control over his behavior during the time of the crime because the brain abnormality affected his behavior.[172] They may also believe that once the structural deficit is treated, the defendant will re-

163. *See* Choe, *supra* note 145, at 47 (finding that the cyst experimental condition produced the greatest and most mitigating effects in both the assault and manslaughter scenarios).
164. *See id.* at 87.
165. *See* Feigenson, *supra* note 14, at 240; Sinnott-Armstrong, *supra* note 117, at 363 (noting that there is much individual variability in brain activation levels).
166. Choe, *supra* note 145, at 46.
167. *Id.*
168. *Id.*
169. *See* Batts, *supra* note 22, at 270. A case study has found that correcting a structural deficit also corrects the associated aberrant behavior. In this case study, a forty-year-old man who exhibited sudden and uncontrollable pedophilia was found to have a tumor in his brain. Once the tumor was removed, his behavior disappeared. While the behavior appeared again, so did his tumor. *See* Jeffrey M. Burns & Russell H. Swerdlow, *Right Orbitofrontal Tumor With Pedophilia Symptom and Constructional Apraxia Sign*, 60 ARCHIVES NEUROLOGY 437, 437–38 (2003).
170. Choe, *supra* note 145, at 46.
171. *Id.*
172. *Id.*

vert back to normal behavior.[173] Thus, mock jurors are more likely to impose a more lenient sentence.[174]

B. Structure/Function Distinction as the Driving Explanation

This Subpart begins by reevaluating the empirical studies discussed above in light of the structure/function paradigm. Again, the conventional wisdom is that the actual visual impact of neuroimages is overpersuasive and hence, prejudicial and lacks probative value. The McCabe and Castel study (in which the addition of fMRI images to a scientific article increased judgments of credibility),[175] the Gurley and Marcus study (in which MRI scans increased the likelihood of a verdict of NGRI),[176] and the Keehner et al. study (in which a text passage accompanied by a three-dimensional fMRI image increased judgments of credibility)[177] support the conventional wisdom. However, the conventional wisdom does not account for all the studies discussed above since some experiments found that neuroimages do not produce a significantly additive effect. The Schweitzer and Saks study (in which MRI scans did not independently increase mock jurors' willingness to find a defendant NGRI),[178] the Gruber and Dickerson study (in which the addition of an fMRI image did not impact judgments of scientific reasoning and credibility in an article),[179] and the Saks et al. study (in which the fMRI image did not affect mock jurors' sentencing decision)[180] all show that neuroimages do not independently influence judgments. Moreover, when other experiments attempted to replicate the McCabe and Castel study as well as the Keehner et al. study, they all failed to find the same effects.[181] This Subpart reexamines these studies to show that the structure/function paradigm succeeds in what the conventional wisdom fails to do.

1. Reevaluating the Empirical Studies Under the Structure/Function Paradigm

First, the structure/function paradigm leads to a different explanation for results in the experiment performed by Gurley and Marcus. Their experiment used

173. *Id.*
174. *Id.*
175. McCabe & Castel, *supra* note 114, at 349.
176. Gurley & Marcus, *supra* note 122, at 93.
177. Keehner et al., *supra* note 125, at 425.
178. Schweitzer & Saks, *supra* note 27, at 603.
179. Gruber & Dickerson, *supra* note 128, at 944.
180. Saks et al., *supra* note 148, at 13.
181. *See* Hook & Farah, *supra* note 27, at 1404; Michael et al., *supra* note 27, at 723; Schweitzer et al., *supra* note 27, at 506–07.

an MRI scan to show extensive physical damage to the prefrontal cortex.[182] The authors proposed that mock jurors see the neuroimage as a more tangible, concrete piece of evidence,[183] suggesting that the image itself significantly persuaded mock jurors to render a verdict of NGRI. However, using the new paradigm, it should be noted that the study used a structural deficit: reduced volume in the prefrontal cortex area.[184] Thus, the loss in brain matter may drive the result of this study, instead of the visual power of the MRI scan itself.

This paradigm also explains the Schweitzer and Saks study. Schweitzer and Saks also used MRI scans to show physical damage to a large area of the frontal lobe.[185] Although the authors did not find that the MRI scan had an independent effect, they found that the neuroscience-based evidence of a structural abnormality was more persuasive than evidence based on psychological evidence or on anecdotal evidence from family members.[186] Structural deficits influence jurors' judgments such that they are significantly more likely to render a verdict of NGRI. Thus, physical damage in the brain, regardless of whether there is a neuroimage or not, is extremely persuasive.

On the other hand, laypeople do not view functional abnormalities as causally potent. Thus the structure/function paradigm sheds new light on the study performed by Gruber and Dickerson.[187] The authors used an fMRI scan and found that the fMRI scan did not produce significant effects on judgments of credibility and of scientific reasoning.[188] Their broad-based conclusion that neuroimages lack persuasive power[189] can better be explained by the structure/function paradigm. Functional abnormalities, unlike structural deficits, lack persuasiveness and do not influence laypeople's judgments because they are viewed as variable and less treatable. Also, these types of brain abnormalities are not viewed as proximal determinants of behavior because they are not concrete, physical causes like structural abnormalities.

However, the findings of McCabe and Castel, and of Keehner et al. appear to undermine the structure/function paradigm. The McCabe and Castel study used an fMRI scan and found that when such a neuroimage accompanied a scientific article explaining cognitive neuroscience data, the article was viewed as

182. Gurley & Marcus, *supra* note 122, at 89.
183. *Id.* at 94.
184. *See id.* at 89.
185. Schweitzer & Saks, *supra* note 99, at 598.
186. *Id.* at 603.
187. *See* Gruber & Dickerson, *supra* note 128.
188. *Id.* at 944.
189. *Id.* at 944.

significantly more credible.[190] The Keehner et al. study also found a similar effect on judgments of credibility, but only when using a highly realistic, three-dimensional fMRI image.[191] At first glance, neither study fits the structure/function paradigm because functional abnormalities seem to influence laypeople's judgments. However, both studies were accompanied by a number of methodological errors including using a within-subjects design.[192] Thus, when Michael et al., Hook and Farah, and Schweitzer et al. corrected for these methodological errors, and then conceptually as well as identically replicated the McCabe and Castel experiment, these authors failed to replicate McCabe and Castel's results.[193] The fMRI scan did not produce significant effects on laypeople's judgments of credibility.[194] Similarly, when Schweitzer et al. corrected for the methodological errors and then conceptually replicated the Keehner et al. study, the authors were unsuccessful.[195] That is, even the highly realistic, three-dimensional fMRI image did not significantly increase laypeople's judgments of credibility.[196] These recent studies suggest that the findings of the McCabe and Castel study as well as of the Keehner et al. study are inaccurate. Thus, setting aside the McCabe and Castel study and the Keehner et al. study, the findings of these recent studies further support the structure/function paradigm since they show that functional abnormalities lack persuasiveness.

What appears to be more problematic for the structure/function paradigm is the Saks et al. study. The authors found that a functional abnormality (without the

190. McCabe & Castel, *supra* note 114, at 349.
191. Keehner et al., *supra* note 125, at 425–26.
192. Recent publications criticize the Keehner et al. study. *See* Farah & Hook, *supra* note 117, at 89 (noting that the Keehner et al. study observed a significant effect because it used a within-subjects design); Hook & Farah, *supra* note 27, at 1398 (similarly noting that the Keehner et al. study used a within-subjects design); Michael et al., *supra* note 27, at 720 (noting that there was no experimental control condition; that is, a condition where subjects evaluated the same article without a brain image). They also criticize the McCabe and Castel study. *See* Farah & Hook, *supra* note 117, at 88 (noting that the conditions in the McCabe and Castel study were not informationally equivalent such that subjects would find the fMRI condition as more persuasive, not because of the neuroimage itself, but because the fMRI condition provided additional support and information); Hook & Farah, *supra* note 27, at 1389–99 (noting that the sample population in the McCabe and Castel study was not diverse because it consisted of university students who are not representative of the larger population); Schweitzer et al., *supra* note 128, at 361 (criticizing the McCabe and Castel study because subjects were evaluating a neuroscience article, which may bias subjects to already find the article more credible when accompanied by a brain image and also noting that the first two experiments were performed using a within-subjects design).
193. *See* Hook & Farah, *supra* note 27, at 1404; Michael et al., *supra* note 27, at 723; Schweitzer et al., *supra* note 27, at 506.
194. *See* Hook & Farah, *supra* note 27, at 1404; Michael et al., *supra* note 27, at 723; Schweitzer et al., *supra* note 27, at 506.
195. Schweitzer et al., *supra* note 27, at 506–07.
196. *Id.* at 507.

fMRI image) did affect capital sentencing decisions for a defendant diagnosed with schizophrenia.[197] However, it is important to note that the same functional abnormality (without the fMRI image) did not affect capital sentencing decisions for a defendant diagnosed with psychopathy.[198] This suggests that there is something about the diagnoses of psychopathy and schizophrenia, rather than the brain abnormality, that influences laypeople's judgments. Thus, in light of this study, this Comment introduces a clarifying principle to the structure paradigm. The structure/function paradigm does not purport to argue that functional brain abnormalities will never be persuasive or that structural brain abnormalities will always be overpersuasive. There may be other mitigating or even aggravating evidence that outweighs any sort of evidence of a brain abnormality, or that interacts with the brain abnormality to make it more causally potent.

Table 1 below presents a summary of the studies discussed in this Subpart and highlights that structural brain abnormalities may drive the persuasive effect of neuroscience evidence. With the exception of the Saks et al. study, every time the neuroscience-based condition significantly affected subjects' judgments, the brain abnormality presented to subjects was a structural deficit, not a functional deficit.

TABLE 1.

Studies	**Did the General Neuroscience-Based Condition Significantly Affect Subjects' Judgments?**	**Independent Effect of Neuroimage**	**Type of Neuro-image**	**Structural Abnor-mality**	**Func-tional Abnor-mality**
Gurley & Marcus	Yes	Yes	MRI	Yes	No
Gruber & Dickerson	No	No	fMRI	No	Yes

197. Saks et al., *supra* note 148, at 14 (noting that mock jurors were significantly less likely to give a death sentence verdict for a defendant diagnosed with schizophrenia compared to the control condition). However, these effects disappeared in the fMRI image condition. *Id.* (noting that when the fMRI image accompanied the general neuroscience evidence for a defendant diagnosed with schizophrenia, there were no significant differences in sentencing decisions compared to the control condition).

198. *Id.* at 13–14 (noting that there were no significant differences in sentencing decisions for a defendant diagnosed with psychopathy compared to the control condition). Moreover, when the fMRI image accompanied the general neuroscience evidence of a functional abnormality, no significant effects were observed. *Id.* at 14.

Studies	Did the General Neuroscience-Based Condition Significantly Affect Subjects' Judgments?	Independent Effect of Neuroimage	Type of Neuro-image	Structural Abnor-mality	Func-tional Abnor-mality
McCabe & Castel (in light of Michael et al., Hook & Farah, and Schweitzer et al.)	N/A (there was no general neuroscience-based condition)	No	fMRI	No	Yes
Keehner et al. (in light of Schweitzer et al.)	N/A (there was no general neuroscience-based condition)	No	fMRI	No	Yes
Saks et al.	Yes (with respect to sentencing decisions)	No (with respect to sentencing decisions)	fMRI	No	Yes
Schweitzer & Saks	Yes	No (other neuroscience-based conditions without neuroimages also significantly increased subjects' willingness to find the defendant NGRI)	MRI	Yes	No

2. The Structure/Function Paradigm Applied to Actual Cases

Although the structure/function paradigm resolves the inconsistencies in the empirical studies that the conventional wisdom does not, all of these studies arguably lack ecological validity.[199] Thus, critics could conclude that we do not know whether the conventional wisdom or the structure/function paradigm is the actual explanation for the overpersuasiveness of neuroscience evidence in real cases. Taking the five cases that are repeatedly cited in the legal literature as evidence bolstering the conventional wisdom, this Subpart shows how the structure/function paradigm provides a more consistent explanation for these cases.

Arguably, the most famous example of a defendant using neuroimaging evidence was John W. Hinckley, Jr.[200] In 1981, Hinckley attempted to assassinate President Ronald Reagan.[201] The defense successfully introduced CT scans of Hinckley's brain into evidence in order to support his insanity defense.[202] The CT scans showed loss of brain tissue and the defense expert witnesses proposed that this loss correlated with having schizophrenia.[203] Hinckley was ultimately found NGRI.[204] Although there are a multitude of other explanations for this

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199. Ecological validity is defined as the capacity to generalize observations made in laboratory studies to the real world. *See* David L. Breau & Brian Brook, *"Mock" Mock Juries: A Field Experiment on the Ecological Validity of Jury Simulations*, 31 LAW & PSCYHOL. REV. 77, 89–92 (2007). However, some have noted that few differences exist between empirical studies and observations of real world phenomena, and that it is feasible to generalize simulation studies to the behavior of real jurors. *See, e.g.*, Brian H. Bornstein, *The Ecological Validity of Jury Simulations: Is the Jury Still Out?*, 23 LAW & HUM. BEHAV. 75, 88 (1999).

200. *See* United States v. Hinckley, 493 F. Supp. 2d 65 (D.D.C. 2007).

201. *E.g.,* Dumit, *supra* note 91, at 174. Hinckley's pathological obsession with the movie *Taxi Driver*, starring Jodie Foster, led him to reenact a number of events in the movie. WILLIAM J. WINSLADE & JUDITH WILSON ROSS, THE INSANITY PLEA: THE USES & ABUSES OF THE INSANITY DEFENSE 185–86 (1983).

202. LINCOLN CAPLAN, THE INSANITY DEFENSE AND THE TRIAL OF JOHN W. HINCKLEY, JR. 81 (1984).

203. Hinckley's brain had reduced gray matter and enlarged sulci. *See* Appelbaum, *supra* note 23, at 21; Joseph H. Baskin et al., *Is a Picture Worth a Thousand Words? Neuroimaging in the Courtroom*, 33 AM. J. L. & MED. 239, 244 (2007); Dumit, *supra* note 91, at 174. Whether this brain abnormality is associated with development of schizophrenia, however, has been widely contested. People with sulci wider than that of Hinckley's brain are known to exhibit normal behavior. Moreover, Hinckley lacked the structural abnormality that is more highly correlated with schizophrenia: enlarged ventricles. *E.g.,* Khoshbin & Khoshbin, *supra* note 1, at 184; Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 22, at 1252; Daniel R. Weinberger et al., *Lateral Cerebral Ventricular Enlargement in Chronic Schizophrenia*, 36 ARCHIVES GEN. PSYCHIATRY 735, 739 (1979).

204. Eyal Aharoni et al., *Can Neurological Evidence Help Courts Assess Criminal Responsibility? Lessons From Law and Neuroscience*, 1124 ANNALS N.Y. ACAD. SCI. 145, 150 (2008).

verdict,[205] this Comment argues that a structural deficit in Hinckley's brain worked to mitigate the outcome of his trial. The reduced volume of gray matter was a persuasive explanation as to the cause of Hinckley's schizophrenia because it is a physical cause and thus is perceived as a strong determinative factor of behavior. Also, the structural deficit may have been perceived as stable—such that it affected Hinckley's behavior during the commission of the crime—as well as treatable.

On the other hand, supporters of the conventional wisdom argue that the visual power of the CT scan unduly persuaded jurors.[206] They point to the fact that CT scans were shown to the jury: one taken soon after the crime and another taken a year later.[207] What they fail to point out, however, is that the judge, worried about the visual impact of the scans, took a number of measures to reduce the visual power of the structural neuroimages.[208] The scans were projected on a tiny screen across a large room from the jury, the courtroom lights were not dimmed, and ultimately the scans looked like "slices of bruised and misshapen fruit."[209] The conventional wisdom fails to account for this verdict because even though the CT scans were introduced, effectively no one saw them or was significantly influenced by them. Thus, the structure/function paradigm is a better theory because jury members may have been persuaded of a structural biological abnormality explaining Hinckley's mental disease regardless of whether they saw the CT scans.

In *People v. Holt*,[210] the defendant was convicted of capital murder and, like Hinckley, was able to introduce a neuroimage.[211] However, in this case, the neuroimaging evidence was admitted during the sentencing phase and was linked to functional abnormalities in the defendant's brain.[212] The PET scan showed that the defendant's temporal lobes and part of his frontal lobe were two standard deviations below normal activity levels.[213] The defense expert witness testified that the defendant therefore had lower metabolic activity compared to

205. People have attributed the verdict to the leniency of the insanity defense, which led to dramatic reforms of the insanity defense and in some cases eliminated the NGRI plea in many jurisdictions. *See id.*; Rendell, *supra* note 83, at 411; *see also* WINSLADE & ROSS, *supra* note 201, at 196 (noting after the Hinckley trial, nine bills were introduced in the U.S. House of Representatives and four bills in the U.S. Senate to revise the insanity defense).
206. *See* Khoshbin & Khosbin, *supra* note 1, at 184.
207. *See* CAPLAN, *supra* note 202, at 85.
208. *Id.*
209. *Id.*
210. 937 P.2d 213 (Cal. 1997).
211. *Id.* at 231.
212. *Id.*
213. *Id.*

normal people.[214] This lower metabolic activity was then linked to aberrant behavior including abnormal judgment and difficulty planning, as well as "emotional system damage."[215] On appeal, the court concluded that even in light of the PET scan evidence as well as other mitigating factors, there was no basis for concluding that death was a disproportionate penalty.[216] The court doubted that the functional brain abnormality was the cause of the defendant's action and also did not believe that at the time of the crime the defendant did not know what he was doing and what he was doing was wrong.[217]

Although this case is repeatedly cited in the legal literature as evidence of the potential danger of using neuroimages, the conventional wisdom fails to explain its result. If bright, multicolored lights in PET scans sway jurors, then the defendant should not have received the death penalty. All of the prejudicial visual characteristics of the PET scan should have rendered the jurors helpless to the "seductive allure" of neuroimages. However, they did not. The conventional wisdom lacks the capacity to explain what really occurred in the courtroom during the sentencing decision. Conversely, the structure/function paradigm offers a better explanation. Unlike Hinckley, who had structural deficits in his brain, the defendant in *Holt* had a functional abnormality. Under the structure/function paradigm, functional abnormalities have less causal potency. Moreover, brain activity levels vary significantly even across normal individuals.[218] Therefore, jurors may have believed that the defendant's brain could have been functioning normally during the commission of the crime and hence may not have credited this type of neuroscience evidence.

This perception of functional abnormalities is also seen in *State v. Stanko*.[219] In this case, the defendant also presented PET scans showing functional abnormality in his frontal lobes to show that the abnormality impaired his ability to control impulsive behavior and to exercise proper judgment.[220] One of the jurors stated:

> Well, I'll be honest with you when we went in deliberation with that PET scan and all that computerized stuff they did, I said I felt like I'd

214. *Id.*; *see also* Edersheim, *supra* note 117, at 178.
215. *Holt*, 937 P.2d at 231; 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, 289 n.183 (2007).
216. *Holt*, 937 P.2d at 263.
217. *Id.*
218. Feigenson, *supra* note 14, at 240; Sinnott-Armstrong, *supra* note 117, at 363 (noting that there is much individual variability in brain activation levels).
219. State v. Stanko, 658 S.E.2d 94 (S.C. 2008).
220. *Id.* at 95.

> been dazzled by brilliance and baffled with b.s. That's how I felt. I found the state's witness much more credible than the defense . . . .[221]

The juror acknowledged the visual impact, but was not automatically persuaded by it. The juror rather perceived the discussion about a functional abnormality in the defendant's frontal lobe as lacking credibility. His statement suggests that he did not believe that a functional abnormality in the frontal lobe caused impulsive behavior and lack of judgment. Thus, it appears that in this case there was a significant inferential distance between a functional abnormality and aberrant behavior, whereas the inferential distance may be much closer for structural deficits as seen in *Hinckley*. On appeal, the defendant's capital sentence was affirmed.[222]

In *People v. Weinstein*,[223] the defendant introduced neuroimaging scans during the guilt/innocence phase of his murder trial.[224] This time, both MRI and PET scans were introduced to show an arachnoid cyst (a structural deficit) and metabolic imbalances (a functional abnormality) near the cyst.[225] The defense argued that the two abnormalities impaired the defendant's ability to reason, including the defendant's ability to tell right from wrong.[226] After the evidentiary ruling, the prosecution accepted a manslaughter plea—reportedly because of the fear that the neuroimages could unduly sway jurors.[227] This case presents a unique situation because the neuroimaging evidence showed both structural and functional abnormalities. Legal scholars repeatedly cite this case to support the conventional wisdom, arguing that the scans themselves unduly influenced the prosecution such that they were willing to accept a manslaughter plea.[228] The prosecution was most

221. Troy Roberts, *Murder on His Mind: Can Scientific Images Show What's in the Mind of a Murderer?*, 48 HOURS MYSTERY, http://www.cbsnews.com/news/murder-on-his-mind-11-01-2007 (last updated Aug. 31, 2007).
222. *Stanko*, 658 S.E.2d at 98.
223. 591 N.Y.S.2d 715 (Sup. Ct. 1992).
224. *Id.* at 717; Kulynych, *Brain*, *supra* note 101, at 242. The judge admitted such evidence because he found that a psychiatric expert is entitled to consider this type of evidence under the norms of the profession. *Weinstein*, 591 N.Y.S.2d at 721.
225. *Weinstein*, 591 N.Y.S.2d at 717–18. An arachnoid cyst is common and usually benign. *See* Patel et al., *supra* note 5, at 563.
226. Batts, *supra* note 22, at 262; Jones & Shen, *supra* note 87, at 361.
227. 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, 33 (2009); Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 22, at 1251.
228. *See, e.g.*, Khoshbin & Khoshbin, *supra* note 1, at 185; Rosen, *supra* note 17 (noting that even though the judge ruled that the defense could not inform jurors that cysts were associated with violence, the prosecution accepted a plea because of the mere possibility that exhibiting neuroimaging scans would sway the jury). Proponents of the conventional wisdom also argue that the judge was unduly influenced by the high-tech neuroimaging himself because he admitted the evidence absent any independent showing that such evidence was generally accepted in the scientific community. Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 19, at 1262; *see*

likely worried about the prejudicial value of the visual impact of the PET scan on jurors.[229] However, while the concern about the neuroimages' impact on the jurors may have led to the plea bargain, had the case gone to trial, the structure/function paradigm posits that the influence of structural deficits would likely have led to a similar outcome—a verdict of manslaughter.

Lastly, in a recent case involving a heinous triple murder, the defendant, Brian Dugan, attempted to introduce fMRI scans as a mitigating factor during his sentencing proceedings.[230] Dugan's case was sensationalized in the popular media because it is thought to be the first in the world to introduce fMRI scans into evidence during a criminal trial.[231] The defense hired Kent Kiehl, a renowned researcher on psychopathy, to testify that like other psychopaths, Dugan had low brain activity in his amygdala.[232] Although the actual fMRI scans were not admitted, Kiehl used PowerPoint slides of bar graphs and cartoon brains in order to show that Dugan had this functional abnormality and that this functional abnormality is highly associated with impulsivity, antisocial behavior, and lack of empathy.[233] The neuroimaging evidence failed, however, to serve as a mitigating factor.[234] All twelve jurors voted to give Dugan the death penalty.[235]

While neuroimages were admittedly not used in this case, the result could also be explained by the fact that functional abnormalities have considerably weaker causal potency. One juror stated, "I don't think that they were able to present that idea that he had a brain defect. He was a psychopath, but he was not psychotic . . . ."[236] This juror gave the functional abnormality evidence little weight because he did not even view it as a brain defect.[237] Such a statement suggests that unlike the link between a structural abnormality and abnormal behavior, the causal link between a functional abnormality in the brain and aberrant behavior is weak. Functional abnormalities were not viewed as a cause, let alone perceived as stable, such that they could have affected Dugan's behavior during

Dumit, *supra* note 91, at 191. However, the conventional wisdom does not tell the whole story. If the judge admitted the actual scans, but did not admit the link to behavioral abnormality, then the implication is that the causal link is more prejudicial than the images themselves.

229. Rosen, *supra* note 17.
230. Hughes, *supra* note 11, at 340.
231. *Id.*
232. *Id.*
233. *Id.* at 341; *see* Edersheim et al., *supra* note 117, at 187.
234. *See* Greg Miller, *fMRI Evidence Used in Murder Sentencing*, SCI. MAG. (Nov. 23, 2009, 5:45 PM), http://news.sciencemag.org/2009/11/fmri-evidence-used-murder-sentencing.
235. *Id.*
236. Hughes, *supra* note 11, at 342.
237. *Id.*

the commission of the crime. They may also not have been viewed as treatable such that his behavior could be corrected.

Table 2 is a summary of the cases discussed above. The table shows that those cases in which structural abnormalities were presented resulted in reduced punishment, whereas cases in which functional abnormalities were presented did not.

TABLE 2.

Cases	Verdict	Neuroimage (Functional or Structural)	Type of Neuroimage	Structural Abnormality	Functional Abnormality
United States v. Hinckley	NGRI	Structural	CAT	Yes	No
People v. Holt	Death penalty	Functional	PET	No	Yes
State v. Stanko	Death penalty	Functional	PET	No	Yes
People v. Weinstein	Manslaughter (plea bargain)	Both (structural and functional)	MRI, PET	Yes	Yes
Dugan case	Death penalty	None (but functional abnormality evidence was presented)	N/A	No	Yes

This Comment narrowly focuses on these five cases because the legal literature overwhelmingly focuses on them to bolster the conventional wisdom. By applying both the conventional wisdom and the structure/function paradigm to these cases, we can see which of these two theories has greater explanatory power. Using the conventional wisdom, the results of the cases cannot be adequately explained. Every time a neuroimage was introduced, the visual impact of the neuroimage should have held a "seductive allure" over the minds of jurors. The functional neuroimages, with their bright lights and colors, should have rendered the jurors helpless to their visual effect and should have overly persuaded the jurors of the causal link between the functional abnormality and the proposed behavioral change. Thus, functional neuroimages should have mitigated sentencing decisions. However, that did not consistently happen in these cases. Instead, every time a functional neuroimage was introduced, jurors appeared to be suspicious of the proposed causal link. That suspicion translated into actual consequences during the sentencing phase. Defendants who introduced functional neuroimages (Holt, Stanko, and Dugan) all received capital punishment.

In contrast, the structure/function paradigm consistently explains the result of these cases discussed above. In cases in which functional abnormalities were presented, regardless of whether the neuroimage was shown, the defendant's prison sentence was never mitigated. Under the structure/function paradigm, this is most likely because the persuasive power is accorded to the type of abnormality rather than the neuroimage itself. Functional abnormalities do not carry that overpersuasive power because people do not see functional abnormalities as having the same degree of causal potency as structural abnormalities. That is, they do not perceive that abnormal functioning in the brain as causally linked to aberrant behavior. On the other hand, structural abnormalities are viewed as more causally potent and people are overly persuaded that aberrant behavior is caused by some structural deficit in the brain. Such a view translates into reduced sentences.

In addition to the cases discussed above, other cases also suggest that structural abnormalities mitigate punishment decisions,[238] whereas functional abnormalities do not.[239] Thus, the structure/function paradigm appears to be a more

238. Criminal cases that suggest structural abnormalities may mitigate punishment decisions include: *State v. Stuard*, 863 P.2d 881, 902 (Ariz. 1993) (finding that the defendant's mental impairment was a major contributing cause to his conduct and reducing his death penalty sentences to consecutive life in prison sentences where the defendant had organic brain damage that was linked to violent impulses and poor impulse control); *People v. Morgan*, 719 N.E.2d 681, 711–12 (Ill. 1999) (vacating the defendant's capital sentence and remanding for a new sentencing proceeding where the defendant had damage to the subcortical structures in his brain); *State v. Daniel*, 429 S.E.2d 724, 729 (N.C. 1993) (finding that expert testimony linking significant brain atrophy observed on the defendant's CT scan to impaired executive functions was relevant to the defendant's state of mind and that excluding such testimony was prejudicial).

239. Criminal cases that suggest functional abnormalities do not mitigate punishment decisions include: *People v. Rogers*, 304 P.3d 124, 128 (Cal. 2013) (imposing the death penalty where the defendant's PET scan was introduced during the penalty phase showing diminished metabolic activity in the frontal lobe, which was linked to the defendant's inability to control his behavior and make "right" decisions); *Victorino v. State*, 23 So. 3d 87, 106 (Fla. 2009) (imposing the death penalty where the defendant introduced expert testimony during the penalty phase showing that the defendant's brain was abnormal and had lower than normal frontal lobe activity, which was linked to impaired executive function and inability to control aggression); *Hunter v. State*, 8 So. 3d 1052, 1060 (Fla. 2008) (imposing the death penalty where the defense expert psychologist testified that the

promising explanation of why certain neuroscience evidence mitigates sentencing decisions in actual cases. Not every case, however, fits the structure/function paradigm. That is to say that structural abnormalities will not always work to reduce punishment. Again, this introduces an important clarifying principle in the structure/function paradigm. The structure/function paradigm does not purport to state that every time a structural abnormality is introduced, the brain abnormality will reduce punishment. Rather, in light of other mitigating circumstances, a structural abnormality can be more powerful than a functional abnormality In these cases that do not fit the structure/function paradigm, there may be other factors that outweigh any sort of evidence of a brain abnormality regardless of whether it is a structural or a functional brain abnormality. These other factors include the heinousness of the crime, a severe mental disability or disorder, or just conflicting evidence.[240]

Why does it matter that structural abnormalities are perceived as more causally determinative of behavior? The problem is that there may be instances in which the link between the structural abnormality and the proposed behavioral change is tenuous. Studies have shown that the relationship between structural abnormalities and aberrant behavior is inconsistent and widely varied. As early as 1941, scientists demonstrated inconsistencies in autopsies of brains of individuals with behavioral problems.[241] Some subjects with minor behavioral abnormalities possessed significant structural abnormalities, whereas other subjects with major behavioral abnormalities possessed minor structural deficits.[242] Moreover, a structural brain abnormality does not necessarily have a one-to-one relationship with behavioral changes.[243]

defendant's PET scan showed functional deficits in the brain, which were linked to impairments in memory and ability to interpret emotional information as well as the capability to control impulses and actions); *Hoskins v. State*, 702 So. 2d 202, 210–11 (Fla. 1997) (imposing the death penalty despite the introduction of a PET scan showing functional abnormality in the defendant's brain); *State v. Mercer*, 672 S.E.2d 556, 562–63 (S.C. 2009) (imposing the death penalty where the defendant introduced expert testimony during the penalty phase concluding that the defendant's SPECT scan was abnormal and there was an area in the defendant's brain that was not functioning normally).

240. *See, e.g.*, Cooper v. State, 739 So. 2d 82, 85–86 (Fla. 1999) (vacating the defendant's death sentence and sentencing him to life imprisonment with the possibility of parole in twenty-five years where his brain presented functional abnormalities in the frontal lobe, but there was other powerful mitigating evidence such as severe physical abuse as a child, repeated head trauma, and dementia); State v. Holmes, 5 So. 3d 42, 52–53 (La. 2008) (unanimously imposing a death sentence where the defendant's MRI showed only some, but not all of the significant structural abnormalities that were consistent with published reports on fetal alcohol syndrome).

241. *See* D. Rothschild & M.L. Sharp, *The Origin of Senile Psychosis: Neuropathic Factors and Factors of a More Personal Nature*, 2 DISEASES NERVOUS SYS. 49, 49 (1941).

242. *Id.* at 53–54.

243. *See* Tancredi & Brodie, *supra* note 215, at 288.

An example of the lack of consistency between structural abnormalities and behavioral changes can be observed in psychopathic individuals. One study noted that structural abnormalities in the prefrontal cortex have not been observed in all psychopathic or antisocial individuals.[244] For example, psychopathic individuals who were convicted exhibited a reduction in prefrontal gray matter, whereas those psychopathic individuals who were not convicted had similar volume of gray matter to normal controls.[245] However, another study found that psychopathic individuals had no structural abnormalities, just lower activation levels in the superior temporal gyrus (an area in the brain that is known to be involved in processing abstract representations of language)[246] compared to controls when performing a word-processing task.[247] These studies show that the causal link between structural abnormalities and aberrant behavior is not always straightforward. Especially with complex behaviors like psychopathic traits, it is difficult to determine whether a structural abnormality in a certain area of the brain is causally linked to aberrant behavior.

Since the structure/function paradigm posits that structural deficits hold significant persuasive power over judgments, the prejudicial value of the evidence of structural deficits may outweigh its probative value, especially if the causal link to aberrant behavior is weak or ambiguous.

V. DECREASING THE PREJUDICIAL IMPACT OF STRUCTURAL BRAIN ABNORMALITIES IN THE COURTROOM: A ROLE FOR JUDGES

Although structural brain abnormalities are likely to be overpersuasive, judges should not completely exclude such evidence because there may be a number of instances in which its probative value outweighs its prejudicial nature. However, judges should be wary of such evidence and should take affirmative steps to reduce the prejudicial nature of the evidence of structural abnormalities because it may unduly persuade jurors and may serve as a potent mitigating factor.[248] During the sentencing phase, there are two specific points when the judge

244. *See* Glenn, Yang & Raine, *supra* note 55, at 84.
245. Yaling Yang et al., *Volume Reduction in Prefrontal Gray Matter in Unsuccessful Criminal Psychopaths*, 57 BIOLOGICAL PSYCHIATRY 1103, 1106–07 (2005).
246. Kiehl et al., *supra* note 69, at 681.
247. *Id.* at 683.
248. Even functional abnormalities have the potential to be prejudicial because, like structural abnormalities, the link between brain and behavior is sometimes tenuous. Therefore, guidelines should be developed for admitting any neuroscience evidence that purports to link a brain abnormality, whether it is structural or functional, to aberrant behavior. *See* Khoshbin & Khoshbin, *supra* note 1, at 187. In terms of structural abnormalities, these guidelines must be stricter because of their causal potency.

has the opportunity to do so: (1) when the defendant seeks to introduce evidence of a structural brain abnormality linked to aberrant behavior, and (2) during the jury instructions, after the evidence is deemed to be admissible.[249]

If the defendant seeks to present structural abnormalities during the sentencing phase, the judge needs to evaluate whether to admit such evidence for jurors to consider when weighing mitigating and aggravating factors. To determine its admissibility, the judge should focus his questioning on two main issues: (1) the imaging parameters and procedures of the neuroimage, and (2) the strength of the evidence showing the causal link between the structural brain abnormality and the aberrant behavior.[250]

First, the judge should question the imaging parameters and procedures since they are not standardized across neuroimages.[251] This line of questioning is important solely because of the inferences the expert draws from the neuroimage, not because of the neuroimage itself. Thus, the judge should initially determine that the brain abnormality indeed exists by assessing whether the structure of the defendant's brain is significantly different from that of normal controls.[252] The judge should ask whether there is a large enough sample size in the control group to account for normal variance.[253] Also, the judge must verify that the control group is the best reference class for the defendant.[254] For example, the age of the members in the control group should be matched to the defendant's age since studies have shown that there are changes in brain volume due to normal aging processes.[255] Thus, the judge should be wary when a study compares a thirty-year-old's brain to a sixty-year-old's brain because the differences in structure may

249. Judges have a vital role in regulating the admission of neuroimaging evidence because, until recently, there were no guidelines within the neuroscience community on expert testimony concerning neuroimages. *See* CAROLYN C. MELTZER ET AL., GUIDELINES FOR THE ETHICAL USE OF NEUROIMAGES IN MEDICAL TESTIMONY: REPORT OF A MULTIDISCIPLINARY CONSENSUS CONFERENCE 1–2 (2013). A consensus conference in 2012 established a set of guidelines to inform the neuroscience community of the ethical use of neuroimaging in the courtroom. *Id.* at 2. However, these are simply guidelines proposed by a small subset of experts. Thus it is imperative for judges to still maintain an active role in evaluating such neuroimaging evidence.

250. The judge should also inquire into the expert's credentials and require greater expertise when the expert testifies about brain abnormalities linked to aberrant behavior. *See id.* at 3.

251. Brown & Murphy, *supra* note 22, at 1207–08; Meltzer, *supra* note 212, at 1; *cf.* Khoshbin & Khoshbin, *supra* note 1, at 187 (arguing that guidance should be provided to judges regarding the technical validity of neuroimaging techniques). Standardizing the tests, the procedures, and the imaging parameters in neuroimaging technology may be beneficial to applications in the courtroom to achieve more consistent conclusions. Mobbs et al., *supra* note 92, at 699.

252. *See* Brown & Murphy, *supra* note 22, at 1207–08.

253. *See id.*

254. *See id.*

255. Patel et al., *supra* note 5, at 558.

be a result of the natural aging process rather than an abnormality that causes aberrant behavior.

After establishing that the brain abnormality exists, the judge should ensure that the neuroscience research showing the causal link to behavioral changes is scientifically valid and reliable.[256] The judge must look at the methodology, especially the statistical analysis, used in each research study in order to gauge its strength. Although studies published in peer-reviewed science journals are more reliable, the judge should not simply rely on the fact of publication. Instead, it is imperative that the judge conducts his own independent investigation. If the judge determines that the research showing the causal link between the brain abnormality and the aberrant behavior is scientifically valid and reliable, the judge should then ask whether there are studies that contest that causal link or if there are any alternative explanations for the brain abnormality.[257] It would also be instructive to ask whether someone with a similar brain abnormality can function normally, such that the abnormality is rendered null. Evaluating the totality of the neuroscience research, the judge should determine whether the research that purports to show the causal link is sufficiently stronger than the research that refutes the causal link.[258] Thus, the inferences that an expert may draw from a structural abnormality in a neuroimage should be narrow.[259]

The judge's role in diminishing the risk of prejudice does not stop here. If the evidence is deemed admissible, the judge must also shape jury instructions to minimize the risk of prejudice from structural abnormalities.[260] However, the

256. Brown & Murphy, *supra* note 22, at 1208.

257. *Id.* at 1207.

258. The judge may consider admitting research that shows the causal link as well as research that refutes the causal link during the sentencing phase. By doing so, the judge may mitigate the prejudicial nature of just admitting one side of the current neuroscience research. *See, e.g.*, People v. Combs, 101 P.3d 1007, 1016–18 (Cal. 2004) (sentencing the defendant to death where the defense mental health expert testified that the defendant's MRI showed abnormalities and lesions in the defendant's brain, whereas the prosecution's expert psychiatrist concluded that the defendant was not suffering from any organic brain disorder and the lesions were rather caused by age); Hunter v. State, 8 So. 3d 1052, 1060 (Fla. 2008) (sentencing the defendant to death where the defense expert psychologist showed that there were functional deficits in the brain related to inability to control impulses and actions, among other aberrant behavior, whereas the prosecution's expert physician testified that the defendant's PET scan was normal as was his MRI).

259. *See* Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 22, at 1259; *see also* Barth, *supra* note 22, at 515 (noting that experts should offer testimony only about particular characteristics of the defendant).

260. Compton, *supra* note 18, at 347; *see also* Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 22, at 1267. Many courts fear that jurors will defer to expert testimony instead of relying on their own knowledge and judgments. Compton, *supra* note 18, at 348. Thus, there is a fear that jurors will forget their roles as the deciders of fact. *Id.* However, since people are known to trust their own judgment, a jury instruction that encourages jurors to trust their judgment may reduce the undue weight that jurors place on expert testimony. *Id.* at 348–49.

possibility of reducing prejudice should be balanced against the risk that these jury instructions can also prejudice jurors by negating any probative value of structural abnormalities.[261] Still, the two risks are likely to equal out. Since structural abnormalities have a higher probability of overly persuading jurors, the danger that the judge's cautionary instructions will overly influence jurors is better counterbalanced. Thus, jury instructions targeted at neuroscience evidence may be more useful when structural abnormalities are introduced to mitigate sentencing rather than functional abnormalities.

In these jury instructions, the judge should strive to remind jurors of the limitations of neuroscience research as well as to decrease the possibility that jurors will be overly persuaded by structural abnormalities. To illustrate how a judge could do this, this Comment includes a sample jury instruction below:

> (Witness's name) was allowed to testify as an expert. As an expert, (witness's name) can give an opinion because of his/her knowledge, skill, experience, training, and education. (Witness's name) is trained in the field of neuroscience.
>
> There are a couple of points that I would like to remind you when you consider this kind of testimony. First, you may be inclined to believe that if there is something physically different about someone's brain structure like the loss of volume, it will cause the person's behavior to change. I want to caution you that this may or may not be true. A physical difference in a certain area of the brain will not always cause behavioral changes.[262] Also, you should not be persuaded by the amount or size of the physical difference. A bigger physical difference does not necessarily mean that there is a greater chance that a person's behavior will change. However, there has been some neuroscience research that has linked changes in the physical brain structure to changes in behavior or psychological disorders. The results of these studies are not completely certain, but just statistically significant.[263] This means that there is a strong relationship between the physical difference in the brain structure and the behavioral change that is more than just due to chance. Thus, you need to carefully evaluate whether the relationship is sufficient enough to show that in this case, the physical difference in the structure of the brain actually caused the change in behavior during the time of the crime.

261. Compton, *supra* note 18, at 351.
262. *See* Khoshbin & Khoshbin, *supra* note 1, at 186–87.
263. *See* Meltzer et al., *supra* note 249, at 3 (noting that detection of structural or functional brain abnormalities correlate with aberrant behavior but do actually show causation).

> You must consider the expert's opinion when evaluating mitigating and aggravating circumstances. However, you may (1) accept the testimony in whole, (2) accept it in part and reject it in part, or (3) reject it in whole.[264] If you find that the conclusions that the expert drew from the defendant's brain are unreasonable or unsupported, you are free to reject the testimony in whole. If you find the difference in the defendant's brain did cause the proposed change in behavior, you may accept the testimony in whole. You may accept the testimony in part if you believe that there are sufficient differences between the defendant's brain and that of the control group, but the expert's conclusions about the link to behavioral changes are inconclusive or erroneous. Remember not to substitute the expert's opinion with your own judgment or common sense.[265]

For judges to perform those two steps above and to effectively evaluate such neuroscience research, it is imperative that judges have a basic understanding of neuroscience. In an ideal world, judges would be able to read neuroscience research articles and to determine if these articles are applicable, valid, and credible. However, most judges are not trained in the sciences[266] and research in this field is not only complex, but also constantly advancing.[267] Thus, judges should be proactive and should keep up-to-date with neuroimaging technology and with new neuroscience research that may be relevant to the legal field.[268]

264. *See* JUDICIAL COUNCIL OF CALIFORNIA CRIMINAL JURY INSTRUCTIONS (CALCRIM) No. 332 (2012) ("You may disregard any opinion that you find unbelievable, unreasonable, or unsupported by the evidence."); Compton, *supra* note 18, at 352 (providing a sample jury instruction where it instructs jurors to accept the testimony in whole, accept the testimony in part and reject it in part, or reject the testimony in whole).

265. Note that "brain abnormality" was never used because it has the connotation that there is something wrong with the brain. The word "difference" was used instead. Also, note that the term "physical" instead of "structural" was used in the jury instruction. Even though laypeople are likely to understand the word "structure," the word "physical" is more accessible to all laypeople and highlights that the structural abnormality is a physical difference like a lesion or a tumor.

266. *See* Compton, *supra* note 18, at 335 ("[J]udges . . . may not fully understand the limits of the technology and may believe that neuroscience evidence is infallible truth.").

267. Judges might find it useful to read the newly updated *Reference Manual on Scientific Evidence* when confronted with such neuroscience evidence in their courtroom. This manual presents the most relevant research in layman's terms. Recently, a separate chapter on neuroscience evidence was added to the manual. Although the new chapter provides a good primer, it mainly focuses on neuroimages and the limitations of neuroimaging technology. The manual would be more effective if it also included the structure/function paradigm and cautioned judges about introducing evidence of structural brain abnormalities when it is linked to aberrant behavior. Such a change is imperative because judges who are focused on keeping the neuroimages out and letting evidence about structural abnormalities in may be failing to mitigate the prejudicial nature of neuroscience evidence.

268. *See* Kulynych, *Psychiatric Neuroimaging Evidence*, *supra* note 22, at 1267; *see also* Mark A. Rothstein, *The Impact of Behavioral Genetics on the Law and the Courts*, 83 JUDICATURE 116, 120 (1999)

CONCLUSION

Currently, most people are concerned about the visual impact of neuroimages. They fear that neuroimages will overly persuade jurors and render them helpless to the neuroimages' "seductive allure." However, the preoccupation with neuroimages alone may be diverting our attention from what truly drives the prejudicial nature of neuroscience evidence: structural brain abnormalities. Both empirical studies and actual cases suggest that the type of brain abnormality, structural or functional, matters more than the neuroimage itself. Thus, this Comment proposes a new theory, the structure/function paradigm, as a competing theory to the conventional wisdom.

The structure/function paradigm is in its infancy and no peer-reviewed study has explicitly tested this paradigm. So, in order to truly conclude that the structure/function paradigm is a better explanation than the conventional wisdom, empirical research needs to be performed that clearly examines the effect of structural versus functional abnormalities on jurors' perceptions. One idea for a future study is to measure effects of five separate conditions (structural abnormality plus neuroimage, structural abnormality minus neuroimage, functional abnormality plus neuroimage, functional abnormality minus neuroimage, and a control condition without any brain abnormality) on jurors' judgments of culpability, responsibility, and punishment. The results of this experiment would first help determine whether structural abnormalities are more persuasive than functional abnormalities. Secondly, it would tease out whether adding neuroimages significantly changes those same judgments. Hopefully, more empirical studies like this will elucidate whether the structure/function paradigm or the conventional wisdom is the superior theory, or whether there is an alternative explanation.

However, in light of the studies and the cases that exist now, we should be wary of admitting structural abnormalities into the courtroom during the sentencing phase. By failing to mitigate such neuroscience evidence and only concentrating on ways to keep neuroimages out, we may unknowingly admit prejudicial neuroscience evidence into the courtroom.

(explaining that many state courts required a more active role for trial court judges in deciding admissibility and have made effort to provide programs and materials for judges to better understand scientific evidence).