SCANNING FOR JUSTICE: USING NEUROSCIENCE TO CREATE A MORE INCLUSIVE LEGAL SYSTEM

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ABSTRACT

Although they may seem to be worlds apart, on further inspection, neuroscience and the law are not so discordant. Neurolaw is an emerging interdisciplinary field that undertakes to examine how an increased understanding of the human nervous system can lead to a more precise explanation for human behavior, which in turn could inform the law, legislation, and policy. While increased dependence on neuroscience in the courtroom raises evidentiary and normative concerns, its use can also have significant implications for civil and human rights by opening doors for plaintiffs to bring claims that historically have been difficult to prove. One such example is the way neuroscience can obviate the outmoded physical-mental divide in tort law. Courts in the United States have been skeptical of awarding damages for "invisible" injuries, such as PTSD, concussions, neurodegenerative diseases, and emotional pain and suffering, all of which can alter brain structure and function, but often do not manifest physically until it is too late for a person suffering those harms to recover damages in a courtroom. However, as neuroscience technology improves, it can help detect these previously hidden or latent injuries, especially for those in marginalized communities, and begin to uproot entrenched policies that perpetuate health inequality. This Note argues that neuroscience, while not without its shortcomings, has become an

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increasingly important tool to create a fairer, more just, and more rehabilitative justice system.

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INTRODUCTION

> "The age of scanning has dawned in our courtrooms. This is not a technological genie we are going to be able to put back in the bottle."[1]

Imagine you are a young child on your way home from your first day of the second grade. You are riding on the school bus, and are excited, if a little nervous, because it is your first time riding on your own. It has been a long day, and you accidentally fall asleep and miss your stop. You awake later to find yourself in an empty bus, parked in a lot nowhere near your home. For many of us, this might incite feelings of fear, anxiety, and distrust. You might be afraid of going to school the next day, perform poorly if you do, or even become unwell when faced with the prospect of getting on a bus again.

If you brought an action in negligence against the bus driver for an incident like this, it might be difficult to prove in court just how much the experience distressed you. You may not have any outward physical symptoms, but anyone who has had an experience like this can tell you that the lasting psychological effects do not easily fade from the mind. What if those processes going on in your brain causing you to feel fear, anxiety, or distrust could be mapped and shown to prove your distress?

For a young boy named Daniel, this kind of evidence could have been helpful. A psychologist diagnosed Daniel with post-traumatic stress disorder (hereinafter PTSD) after a traumatic experience of being abandoned on a school bus.[2] While the court acknowledged his distress as a real, debilitating injury, it did not find that it qualified as a "physical injury" as required under Kansas tort law and, therefore, Daniel could not recover damages.[3] But what if there was a way to show that the psychological effects from which Daniel was suffering were not based in some existential ether, but had physiological roots in the brain?

The field of cognitive neuroscience has the potential to do just that. Recent advancements in this field should change the way we

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1. Zachary Weiss made this prediction after serving as prosecutor in People v. Weinstein, 591 N.Y.S.2d 715 (N.Y. Sup. Ct. 1992), one of the earliest cases to feature neurological scans in a trial. *See* Zachary Weiss, *The Legal Admissibility of Positron Emission Tomography Scans in Criminal Cases: People v. Spyder Cystkopf*, 1 SEMINARS IN CLINICAL NEUROPSYCHIATRY 202, 202 (1996).
2. Ware v. ANW Special Educ. Coop., 180 P.3d 610, 612 (Kan. Ct. App. 2008).
3. *Id.* at 619.

think about the physical-mental divide in tort law. As a judge wrote in dissent in Daniel's case,

> [R]esearch does not support a categorical distinction between emotional and physical harm . . . "Whatever the best minds of the day might have thought about the difference in physical and emotional harm when tort law came of age, the best minds of today do not support such a stark mind-body dichotomy."[4]

Severe emotional distress is just one type of injury that people all across the world suffer but may not visibly display, even though it can significantly affect one's daily life. Other injuries, such as concussions and neurodegenerative diseases, can also alter brain structure and function, but often do not manifest physically until it is too late for a person suffering those harms to recover damages in a courtroom.[5] Courts in the United States have been skeptical of awarding damages for these injuries for evidentiary and normative purposes, as in Daniel's case. Historically, there has been a lack of adequately objective evidence for claims that we cannot see with the naked eye. In a legal system where resources are limited, courts have required some sort of dividing line to determine harms worthy of compensation. But as technology that analyzes the brain and its functions improves, we can start identifying these previously hidden or latent injuries and rectify gaps for redress in tort and other bodies of law.

This Note focuses primarily on tort law as an essential mechanism for enforcing civil rights in a common law system and a means by which citizens can maintain their human rights on a transnational scale. These rights include, among others, the rights to health,[6] equality before the law,[7] and dignified treatment,[8] as well as a

4. *Id.* at 621 (Green, J., dissenting) (internal citations omitted) (quoting Daniel W. Shuman, *How We Should Address Mental and Emotional Harm*, 90 Judicature 248, 248 (2007)).

5. By the time the damages are identified, a victim might be beyond repair. *See, e.g.*, Emily Kelly, *I'm the Wife of a Former N.F.L. Player. Football Destroyed His Mind*, N.Y. TIMES (Feb. 2, 2018), https://www.nytimes.com/2018/02/02/opinion/sunday/nfl-cte-brain-damage.html (on file with the Columbia Human Rights Law Review) (chronicling just one of many accounts of former professional athletes suffering permanent brain injuries).

6. G.A. Res. 217 (III) A, art. 25, Universal Declaration of Human Rights (Dec. 10, 1948).

7. *Id.* at art. 7.

8. *Id.* at art. 1.

right to due process and to a fair trial in a domestic setting.[9] Neuroscience has become increasingly important in ensuring these rights are protected, and may prove useful as a tool to create a fairer, more just, and more rehabilitative legal framework.[10]

This Note argues that, despite some very serious evidentiary and normative concerns, as neuroscience technology becomes increasingly accurate, less expensive,[11] and more precise[12] in illustrating the ways in which people suffer harm, traditional dichotomies of injury compensation, such as the physical-mental divide, are no longer valid. Instead, the law should compensate based on severity of harm rather than type of injury. Redefining this line in tort law will uphold and advance individual autonomy and normative values inherent in our tort system, resulting in more accurate and objective compensation that utilizes modern technology to help people who would otherwise go without just compensation.

Part I of this Note provides a general overview of the intersection between neuroscience and law and the different technologies involved in examining injury, pain, and emotion in the brain. It then details some of the ways that neuroscience technology is already used or discussed in courtrooms and in legislation. Part II describes how neuroscience technology can be used to advance human and civil rights, particularly in tort law, by helping plaintiffs receive compensation for invisible injuries that previously have been difficult to prove, focusing on case studies of PTSD, mild traumatic brain injuries, and neurotoxicity. Part III of this Note explains a few of the ways that neuroscience technology and its use in the courtroom could backfire or hurt some litigants. It also describes some complications of this technology and explains how it can nonetheless be useful if certain precautions are taken. Part III also suggests a few procedural options for regulating or evaluating neuroscience evidence in civil courtrooms,

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9. U.S. CONST. amends. V, VI.

10. *See* Nancy Gertner, *Neuroscience and Sentencing*, 85 FORDHAM L. REV. 533, 544 (2016) (explaining how neuroscience can help inform a more rehabilitative criminal justice regime).

11. Brain scanning technologies, although still relatively expensive, have been dramatically decreasing in cost. Ian Sample and David Adam, *The Brain Can't Lie*, GUARDIAN (Nov. 20, 2003), https://www.theguardian.com/science/2003/nov/20/neuroscience.science [https://perma.cc/J4QG-PTW3].

12. Adam J. Kolber, *Will There Be a Neurolaw Revolution?,* 89 IND. L.J. 807, 822 (2014) (arguing that neuroscience technology has become increasingly reliable. For example, functional magnetic resonance imaging scans can, at least in controlled experimental contexts, predict with 80% accuracy whether or not a particular subject is in pain).

advocating in particular for a working group that could research, draft, and oversee policy proposals. This Note ultimately argues that, as brain scanning technology becomes increasingly precise and research surrounding it increasingly refined, lessons learned from neuroscience will inevitably influence the law and that, overall, inclusion of neuroscientific evidence in the courtroom is advantageous and desirable for tort litigants whose claims until recently have been unverifiable.

I. NEUROLAW: WHAT IT IS AND HOW IT IS USED

At first glance, neuroscience and the law may seem to be odd bedfellows. However, an increasing amount of scholarship and attention is being addressed to the ways that neuroscience—the scientific study of the structure and function of the nervous system and the brain[13]—may impact law, legislation, and policy.[14] Neuroscience research is rapidly developing and illuminating our understanding of human behavior, motivation, intention, and cognition.[15] Understanding how our brains function from a physiological viewpoint should affect how we think about and normatively construct the law. Because neuroscience is the study of the cognitive processes that underlie human behavior, it ought to have significant implications for legal systems, which are ultimately concerned with the regulation of human behavior. Indeed, it already has.[16]

This Part discusses the intersection of neuroscience and law. Section A describes the neuroscience technologies involved in

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13. *Neuroscience,* OXFORD LIVING DICTIONARIES, https://en.oxforddictionaries.com/definition/neuroscience [https://perma.cc/VXH3-NTUK].

14. *See, e.g.*, Kolber, *supra* note 12, at 808 ("[T]here will indeed be a neurolaw revolution. It may arise . . . from a wave of new brain technologies that will change society and the law in a wide variety of ways.").

15. *See generally* Martha J. Farah, *Neuroethics: the ethical, legal, and societal impact of neuroscience*, 63 ANNU. REV. PSYCHOL. 571 (2012) (exploring how advances in neuroscience impact other fields and discussing the various ethical, legal, and societal implications).

16. There are increasing signs of neuroscience technologies becoming less of a science fiction plot and more of a reality. For example, in the United States, at least two companies, No Lie MRI and Cephos Corp., have offered magnetic resonance imaging-based lie-detection services. Richard Birke, *Neuroscience and Settlement: An Examination of Scientific Innovations and Practical Applications*, 25 OHIO ST. J. ON DISP. RESOL. 477, 482–83 (2010); Eli Aharoni et al., *Neuroprediction of Future Rearrest*, 110 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 6223 (2013).

examining injury, pain, and emotion in the brain. Section B provides background and a general overview of the use of neuroscience in legislation, policy, and the courtroom. Section C addresses some of the ways that these technologies can be used in tort and human rights law specifically, focusing on how they can substantiate the invisible injuries affecting people across the world.[17]

A. Types of Neuroscience Technology

Among the various neuroscience technologies used to examine injury, pain, and emotion in the brain, courts and scholarship to date have focused mostly on functional magnetic resonance imaging (hereinafter fMRI) and positron emission tomography (hereinafter PET) scans and how they reflect the physical processes that take place in the brain.[18]

An fMRI measures blood oxygenation levels in the brain and enables scientists to detect which brain regions are receiving more blood flow.[19] When there are changes in brain activity, such as when a patient feels a painful stimulus, blood flow throughout the brain changes as hemoglobin in the blood carries oxygen to the areas of the brain that are working harder.[20] When the hemoglobin releases oxygen to those areas, it becomes paramagnetic,[21] which triggers a magnetic

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17. Notably, the Office of the United Nations High Commissioner for Human Rights recognizes the "human right of everyone to the enjoyment of the highest attainable standard of physical *and mental* health" (emphasis added). *See Report of the Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health*, U.N. Doc. A/HRC/35/21 (March 28, 2017).

18. These technologies in particular can illustrate the physical processes occurring in our brains in real time. Our brains hold about 100 billion neurons, each one making 1,000 or more connections—"synapses"—to other neurons in which they are constantly giving off and picking up chemicals called neurotransmitters, which communicate information throughout the brain and body. Henry T. Greely, *Neuroscience, Mindreading, and the Courts: The Example of Pain*, 18 J. OF HEALTH CARE L. & POL'Y 171, 171 (2015).

19. John C. Gore, *Principles and practice of functional MRI of the human brain,* 112 J. CLINICAL INVESTIGATION 4 (July 2003), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC162295/pdf/JCI0319010.pdf [https://perma.cc/XDG5-7E8L].

20. *Id.* at 5.

21. Deoxyhemoglobin, present in deoxygenated blood, is paramagnetic; that is, its presence causes a decrease in a magnetic resonance signal. O. Carter Snead, *Neuroimaging and the "Complexity" of Capital Punishment*, 82 N.Y.U. L. REV. 1265, 1285 (2007).

field located inside a magnetic resonance imaging (MRI) scanner.[22] Neuroscientists can track these signals, referred to as the BOLD (blood-oxygen-level dependent) signals, and see how they flow to different areas of the brain over time.

PET scans also measure blood flow in the brain. PET researchers inject a radioactive tracer into the bloodstream and, by tracking its path, can identify neural brain activity in particular areas of the brain.[23] PET and fMRI scans therefore identify the portions of the brain that are activated when a person is experiencing or thinking something, based on the increased quantity of freshly oxygenated blood the regions draw. During a scan, a researcher can measure and correlate the brain areas receiving more blood flow at different time intervals as a participant is asked questions or given a stimulus, such as pain.

Other types of neuroscience technology used to measure abnormalities or disorders in the brain include single-photon emission computed tomography (SPECT), electroencephalography (EEG), quantitative electroencephalography (qEEG), and magnetoencephalography (MEG) scans. These various types of scans can be used, respectively, to distinguish between different types of seizures, to pinpoint defects in auditory and somatosensory areas, to diagnose sleep disorders, and to examine head injuries, tumors, infections, and neurodegenerative diseases.[24] These neuroimaging methods are largely non-invasive, safe, increasingly accessible,[25] and less expensive[26] than other types of scans, such as fMRIs.[27]

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22. *Id.* at 7.

23. Abi Berger, *Clinical Review: How does it Work? Positron Emission Tomography*, BMJ VOLUME 326 (2003), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1126321/pdf/3261449.pdf [https://perma.cc/JSP5-J4BR].

24. Judy Illes, *A Picture is Worth 1000 Words, but Which 1000?, in* NEUROETHICS: DEFINING THE ISSUES IN THEORY, PRACTICE, AND POL'Y 151 (Oxford University Press ed., 2006).

25. *Id.* In numerous countries, including the United States, the prevalence of fMRI machines per population has been steadily increasing. *Number of magnetic resonance imaging (MRI) units and computed tomography (CT) scanners: Selected countries, selected years 1990–2009*, CTRS. FOR DISEASE CONTROL & PREVENTION (2011), https://www.cdc.gov/nchs/data/hus/2011/123.pdf [https://perma.cc/Q9VH-7494].

26. Greely, *supra* note 18, at 190 ("EEG . . . has many advantages over fMRI—it is cheap, portable, and easy to operate.").

27. Although fMRI scans are increasingly inexpensive, the costs of obtaining fMRIs may deter litigants from using them or may be prohibitively expensive for many plaintiffs. *See* Stephen J. Morse, *Neuroimaging Evidence in Law: A Plea for*

However, it is important to keep in mind that functional brain imaging is not necessarily the same thing as mind reading. Researchers warn that "[w]hile fMRI can accurately measure changes in blood flow and oxygen levels, interpreting those changes as reliable indicators of particular types of thought, or as reliable indicators of what a region of the brain is actually doing, requires a series of inferential steps that are not entirely straightforward."[28] Perhaps even more critical is that this technology cannot prove causation. Although differences in brain scans after an emotionally disturbing event may have a corollary relation, this does not mean that the emotionally disturbing event was the cause of those differences, and other events may have contributed to the injury since. Similarly, when trying to image how a plaintiff's pain or injury has changed over time, researchers may need a baseline scan of the plaintiff's pain level before a defendant's wrongful action, which is often absent.[29]

Despite these weaknesses, neuroscientific evidence from fMRIs, PET scans, and other tests is increasingly used in U.S. courtrooms under certain evidence standards,[30] and the rapid growth of neuroscience technology will likely only improve its accuracy and reduce its price.

Modesty and Relevance, *in* NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM 341, 342 (Joseph R. Simpson ed., 2012).

28. Owen D. Jones & Francis X. Shen, *Law and Neuroscience in the United States*, *in* INTERNATIONAL NEUROLAW 353, 356 (Tade Matthias Spranger ed., 2012).

29. Floyd Bloom et al., *Does Neuroscience Give Us New Insights into Drug Addiction?*, *in* A JUDGE'S GUIDE TO NEUROSCIENCE: A CONCISE INTRODUCTION 34 (2010), https://www.sagecenter.ucsb.edu/sites/staging.sagecenter.ucsb.edu/files/file-and-multimedia/A_Judges_Guide_to_Neuroscience%5Bsample%5D.pdf [https://perma.cc/L2L7-SQT2] ("To determine the pattern of activity, the fMRI BOLD signal during pain has to be compared with a baseline condition when there is no pain").

30. *See* FED. R. EVID. 401, 702; Daubert v. Merrill Dow Pharm., Inc., 509 U.S. 579, 589 (1993) (holding that trial judges must determine whether expert testimony is both "relevant" and "reliable"); Frye v. United States, 293 F. 1013, 1014 (D.C. Cir. 1923) (holding that expert testimony must be based on knowledge that has "gained general acceptance in the particular field"). The *Daubert* standard is the law in federal court and over half of the states, while the *Frye* standard is preferred in some jurisdictions including California, Illinois, Maryland, New Jersey, Pennsylvania, and Washington. Amanda C. Pustilnik, *Imaging Brains, Changing Minds: How Neuroimaging Can Transform the Law's Approach to Pain*, 66 ALA. L. REV. 1099, 1148 (2014).

B. The Intersection of Law and Neuroscience

The intersection of law and neuroscience, often dubbed "neurolaw,"[31] has featured prominently in a number of cases and policy debates in the U.S.[32] Scholars, advocates, and judges have invoked neurolaw in a variety of legal fields, including criminal responsibility and sentencing,[33] lie detection,[34] adolescent brain development and

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31. "Neurolaw" is the application of neuroscience findings to legal topics such as criminal, tort, and administrative litigation and justice, agency, intent, and policy. Neil Aggarwal & Elizabeth Ford, *The Neuroethics and Neurolaw of Brain Injury*, 31 BEHAV. SCI. L. 789, 790 (2013).

32. *See generally* Francis X. Shen, *The Overlooked History of Neurolaw*, 85 FORDHAM L. REV. 667, 1043–49 (2016) (discussing how the intersection of neuroscience and the law is centuries old). The number of cases in the U.S. involving neuroscientific evidence doubled from 2006 to 2009 and there are a growing number of criminal cases involving neuroscientific evidence. Jones & Shen, *supra* note 28, at 353.

33. In State v. Nelson, F05-846 (Fla. 11th Cir. Ct. 2010), qEEG evidence was admitted into evidence in a U.S. court for the first time, and contributed in part to the jury voting to sentence the defendant to life in prison instead of the death penalty. One juror commented that "the technology really swayed me . . . after seeing the brain scans, I was convinced this guy had some sort of brain problem." David Ovalle, *Novel defense helps spare perpetrator of grisly murder*, MIAMI HERALD (Dec. 2, 2010), http://www.floridacapitalcases.state.fl.us/Documents/Enewsletter/2010_Articles_December/Novel%20defense%20helps%20spare%20perpetrator%20of%20grisly%20murder.pdf [https://perma.cc/KJ3D-RMG7].

34. There have been various instances in which fMRI and EEG-based lie detection evidence was proffered in U.S. courts. *United States v. Semrau* presented the first evidentiary hearing in federal court on the admissibility of fMRI lie-detection evidence. 693 F.3d 510, 521 (6th Cir. 2012). Although Magistrate Judge Pham ultimately did not admit the evidence under Federal Rule of Evidence 702, he wrote that "in the future, should fMRI-based lie detection undergo further testing . . . this methodology may be found to be admissible." Amended Report and Recommendation, United States v. Semrau, 2010 WL 6845092, at *12 n.18 (W.D. Tenn. June 1, 2010).

juvenile justice,[35] morality,[36] free will,[37] risk and information processing in addicts,[38] brain death and injury,[39] judge and jury bias,[40] and tort law,[41] among others. The use of neuroscience data as evidence in U.S. courtrooms has risen sharply in the past decade.[42] Outside of the courtroom, neuroscience is also widely cited in various types of legislative bills,[43] especially relating to brain injury,

35. *See* Graham v. Florida, 560 U.S. 48, 117 (2010) (majority opinion by Justice Kennedy explicitly citing "brain science" research when considering juvenile offenders).

36. Neuroscience has shed light on some of the ways people think about moral conundrums, such as the classic trolley hypothetical. Experimenters found that the brain region associated with deliberate problem solving and self-control, the dorsolateral prefrontal cortex, was especially active in an fMRI scan when subjects contemplated the utilitarian option of pulling the lever and saving the greatest number of lives. By contrast, the ventral medial prefrontal cortex, an emotional center of the brain, was active when subjects imagined harming the one individual even if it would have saved others. 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 (on file with the Columbia Human Rights Law Review).

37. *See* Steven K. Erickson, *Blaming the Brain*, 11 MINN. J.L. SCI. & TECH. 27, 28 (2010) (evaluating how cognitive neuroscience research may disrupt long-standing norms of personal responsibility).

38. *See* Brent Garland & Mark S. Frankel, *Considering Convergence: A Policy Dialogue About Behavioral Genetics, Neuroscience, and Law*, 69 LAW & CONTEMP. PROBS. 101, 104 (2006) (noting that "[n]euroscience has shown that the brains of addicts are distinct from those of non-addicts").

39. *See* Davinia Fernández-Espejo & Adrian M. Owen, *Detecting Awareness After Severe Brain Injury*, 14 NATURE REVIEWS NEUROSCIENCE 801, 807 (2013).

40. Lisa G. Aspinwall et al., *The Double-Edged Sword: Does Biomechanism Increase or Decrease Judges' Sentencing of Psychopaths?*, 337 SCIENCE 846, 846 (2012). One study found that certain extraneous variables, such as the time of day, affect a judge's decision to grant parole. Areas of the brain that are used for more complex reasoning, such as the dorsolateral prefrontal cortex, show less activity when other areas concerned with more basic bodily needs like hunger, such as the temporal lobe, are more active. Shai Danziger et al., *Extraneous Factors in Judicial Decisions*, 108 PROC. NAT'L ACAD. SCI. 6889, 6892 (2011).

41. Jean M. Eggen & Eric J. Laury, *Toward a Neuroscience Model of Tort Law: How Functional Neuroimaging Will Transform Tort Doctrine,* 13 COLUM. SCI. & TECH. L. REV. 235, 274 (2012).

42. Nita A. Farahany, *Neuroscience and Behavioral Genetics in US Criminal Law: An Empirical Analysis*, 2 J.L. & BIOSCIENCES 485, 486 (2016) (finding that the number of judicial opinions citing some sort of neuroscientific defense more than doubled between 2007 and 2012).

43. Francis X. Shen, *Neurolegislation: How U.S. Legislators Are Using Brain Science*, 29 HARV. J.L. & TECH. 495, 498 (2016) (finding that "from 1992 through 2009 . . . brain science has been mentioned in nearly 1000 bills").

medical insurance,[44] mental health, education and early childhood interventions, and veterans' affairs.

Neuroscience technology has had varying influence in the criminal courtroom context thus far.[45] Brain scans have been presented to mitigate a defendant's sentence,[46] to show that a defendant is incompetent to stand trial, and to prove that a defendant did not have the requisite mens rea at the time of the crime, though the scans are not uniformly admitted or successful. Sometimes the scans merely demonstrate correlation rather than causation—at least in a courtroom's eye. For instance, in *People v. Goldstein*, a defendant who pushed a woman in front of a subway train to her death sought to introduce a PET image of a brain abnormality in an effort to prove an insanity defense of schizophrenia.[47] While the prosecution conceded that Goldstein suffered from schizophrenia, the court excluded the PET scan from evidence because even though it demonstrated a brain abnormality, it would not actually be probative as to the mens rea element of the crime, "since a diagnosis of schizophrenia does not preclude per se that a defendant is capable of such comprehension."[48] Cases such as this one illustrate that, at least in criminal contexts in the United States, neuroscientific data can be useful as an evidentiary tool, though a court may reject the admissibility of the data if it cannot prove a causal basis for a defendant's actions or if it is not used in conjunction with corroborating evidence.

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44. Stacey A. Tovino, *Will Neuroscience Redefine Mental Injury? Disability Benefit Law, Mental Health Parity Law, and Disability Discrimination Law*, 12 IND. HEALTH L. REV. 695, 697–727 (2015) (exploring the role that brain scanning technologies play in securing health insurance coverage, social security eligibility for mental health conditions, and in officially recognizing gender-specific mental health conditions like premenstrual syndrome and postpartum depression).

45. Eggen & Laury, *supra* note 41, at 238 ("[The] criminal courtroom has become an early testing ground for the application of the studies to cognitive mental states in the law. The courts have shown interest, tempered by caution, and suspicion of the evidence's reliability.").

46. Introducing evidence to demonstrate brain abnormalities or injuries for the purpose of mitigating sentencing has been one of the more common uses of neuroscience in the courtroom. For example, an Oregon boy convicted of killing and injuring fellow students introduced images showing brain abnormalities and was granted a more lenient sentence due to his mental illness. State v. Kinkel, 56 P.3d 463, 467 (Or. Ct. App. 2002).

47. People v. Goldstein, 786 N.Y.S.2d 428, 432 (N.Y. Sup. Ct. 2004), *rev'd on other grounds*, 843 N.E.3d 119 (N.Y. 2005).

48. *Id.*

Neuroscience evidence has also been used in various cases and legislation[49] concerning juvenile justice. In *Miller v. Alabama*, the United States Supreme Court cited brain science findings regarding impulse control, planning, and risk avoidance in holding that mandatory sentences of life without the possibility of parole are unconstitutional for juvenile offenders.[50] That case, and at least twenty others, have relied on an affidavit written by Ruben Gur, a national PET expert, arguing that adolescents are not as capable of controlling their impulses as adults because the development of neurons in the prefrontal cortex is not complete until the early 20s.[51] Similarly, in *Graham v. Florida* the Supreme Court cited neuroscientific and psychological data on adolescent development when it struck down, under the Eighth and Fourteenth Amendments, sentencing juveniles to life in prison without parole for non-homicide crimes.[52]

Courts have also considered neuroscience evidence in civil matters. In his dissent in *Brown v. Entertainment Merchants Association*, Justice Breyer cited "cutting-edge neuroscience" to

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49. For instance, the neuroscience of adolescent development featured prominently in a 2011 California Senate Bill which allowed juveniles sentenced to life without parole to submit a request to have a new sentencing hearing. CAL. PENAL CODE § 1170(d) (West 2011).

50. Miller v. Alabama, 567 U.S. 460, 471–73, 472 n.5 (2012) (favorably citing neuroscience evidence presented in amicus briefs, Justice Kagan wrote for the majority, "We reasoned that those [neurological] findings—of transient rashness, proclivity for risk, and inability to assess consequences—both lessened a child's 'moral culpability' and enhanced the prospect that, as the years go by and neurological development occurs, his 'deficiencies will be reformed'").

51. Declaration of Ruben C. Gur, Ph.D. at 15, Patterson v. Texas, 536 U.S. 984 (2002), https://www.americanbar.org/content/dam/aba/publishing/criminal_justice_section_newsletter/crimjust_juvjus_Gur_affidavit.authcheckdam.pdf [https://perma.cc/6DA6-88CW] ("The evidence now is strong that the brain does not cease to mature until the early 20s in those relevant parts that govern impulsivity, judgment, planning for the future, foresight of consequences, and other characteristics that make people morally culpable.").

52. Graham v. Florida, 560 U.S. 48, 68 (2010) ("[D]evelopments in psychology and brain science continue to show fundamental differences between juvenile and adult minds."). *See also* Roper v. Simmons, 543 U.S. 551 (2005), in which the Supreme Court struck down the death penalty for offenders who committed crimes when they were under the age of 18 partially based on an affidavit that argued that because adolescents' prefrontal cortices are not fully developed, they are less able than adults to control their impulses and should not be held fully accountable "for the immaturity of their neural anatomy . . . [because] [t]o a degree never before understood, scientists can now demonstrate that adolescents are immature . . . in the very fibers of their brains." Brief for American Medical Association et al. as Amici Curiae Supporting Respondent at *10, Roper v. Simmons, 543 U.S. 551 (2005) (No. 03-633).

support the argument that violent video games are linked to more aggressive behavior.[53] In other cases, neuroscientific evidence has been successful in proving mental incapacity. For example, in *Van Middlesworth v. Century Bank and Trust Co.*, a defendant introduced brain scans to prove his mental incompetency, resulting in the court ruling that the real estate contract that he signed was void.[54]

C. Neuroscience as a Burgeoning Tool in Tort and Human Rights Claims

Scholars have debated the use of neuroscience evidence in criminal sentencing mitigation at length,[55] but an increased reliance on neuroscience in the courtroom, in legislation, and in regulation can also have significant implications for civil and human rights[56] and can open many new doors for plaintiffs to bring claims, such as in tort law.[57] By pinpointing cognitive responses with objective technology, neuroscience tools and research can provide substantiation for "invisible" tort injuries[58] that historically have been difficult to prove

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53. Brown v. Entm't Merchs. Ass'n, 564 U.S. 786, 852 (2011) (Breyer, J., dissenting).

54. Van Middlesworth v. Century Bank & Tr. Co., No. 215512, 2000 Mich. App. LEXIS 2369, at *6 (Ct. App. May 5, 2000).

55. Francis X. Shen, *Law and Neuroscience 2.0*, 48 ARIZ. ST. U. L. REV. 1043, 1049–50 (2016) (remarking that neurolaw often focuses only on criminal law, and that many of its other intersections with the law are ripe for discussion).

56. Even President Barack Obama called attention to the potential impact of neuroscience on human rights and how it might be used appropriately in matters relating to moral responsibility, personal agency, and the criminal justice system. *See* PRESIDENTIAL COMM'N FOR STUDY OF BIOETHICAL ISSUES, GRAY MATTERS: INTEGRATIVE APPROACHES FOR NEUROSCIENCE, ETHICS AND SOCIETY vi–vii (vol. I, 2014). In 2013, he called on Congress to invest millions of dollars in new brain research. Press Release, White House Office of Science and Technology Policy, Obama Administration Proposes Doubling Support for The BRAIN Initiative (March 2014), https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/FY%202015%20BRAIN.pdf [https://perma.cc/E3TR-XH55].

57. Marcello Ienca & Roberto Andorno, *Towards New Human Rights in the Age of Neuroscience and Neurotechnology*, 13 LIFE SCI., SOC'Y & POL'Y (Apr. 26, 2017), at 2, 8 (writing that "international human rights law does not make any explicit reference to neuroscience. In contrast to other biomedical developments . . . neurotechnology still largely remains a *terra incognita* for human rights law").

58. "Invisible injuries" may be defined as those that affect a person's enjoyment of life but are not visible to the naked eye or do not readily show up on traditional technologies such as X-rays. Some examples include mTBIs, PTSD, chronic pain, fibromyalgia, emotional distress, and neurobiological toxins. *See*

beyond a plaintiff's testimony, such as PTSD, mild traumatic brain injuries (hereinafter mTBIs), toxic exposure, and emotional pain and suffering. Neuroscience technology's ability to reveal the pain response in an individual's brain could reform how we think about tort law and what compensation may be due to litigants. Incorporating this emerging field into law would be especially beneficial for the rights of people in marginalized communities, such as racial and ethnic minorities,[59] prison inmates, indigent people,[60] abuse victims, and invisible injury victims,[61] whose pain and suffering traditionally is underreported.

PET, fMRI and other brain science technologies can shed light on how a person's experiences affect cognitive functions that are outwardly undetectable or produce visible symptoms only after it is already too late for a plaintiff to be made whole.[62] In tort law specifically, it is generally more feasible for plaintiffs to recover damages for physical injuries than for psychological or invisible

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Betsy J. Grey, *The Future of Emotional Harm*, 83 FORDHAM L. REV. 2605, 2651 (2015).

59. It is well-documented that lower-income and racial minority communities, particularly in urban areas, experience an elevated risk for health issues that stem from invisible or late-manifesting harms such as neurotoxins. This Note argues that entrenched policies such as the physical-mental divide in tort law perpetuate these health inequities, since individuals in these communities are also often less able to acquire adequate data to prove the injuries they are suffering from and, moreover, tend to underreport their pain. Emily A. Benfer, *Contaminated Childhood: How the United States Failed to Prevent the Chronic Lead Poisoning of Low-Income Children and Communities of Color,* 41 HARV. ENVTL. L. REV. 493, 503–04 (2017); Jana Mossey, *Defining racial and ethnic disparities in pain management*, 469 CLINICAL ORTHOPAEDICS & RELATED RES. 1859, 1859 (2011).

60. Peter S. Spencer & Valerie S. Palmer, *Interrelationships of Undernutrition and Neurotoxicity: Food for Thought and Research Attention*, 33 NEUROTOXICOLOGY 605, 606 (2012).

61. Neuroimaging evidence provides experts with scientific facts upon which they can draw inferences "'that not only support the [litigant's] story but may be the only source for it.' Excluding such evidence would 'deprive the [litigant] of the voice the Constitution guarantees.'" Adam Teitcher wrote this about criminal defendants but it holds true for civil litigants as well. Adam Teitcher, Note, *Weaving Functional Brain Imaging into the Tapestry of Evidence: A Case for Functional Neuroimaging in Federal Criminal Courts*, 80 FORDHAM L. REV. 355, 393 (2011) (footnote omitted) (quoting CHRISTOPHER SLOBOGIN, PROVING THE UNPROVABLE: THE ROLE OF LAW, SCIENCE, AND SPECULATION IN ADJUDICATING CULPABILITY AND DANGEROUSNESS 55 (2007)).

62. For example, neurocognitive impairment as a result of concussions or neurotoxins may not outwardly manifest until days, weeks, or years later. *See infra* Part II.

injuries, with limited exceptions.[63] However, with the advent of neuroscientific data, more courts and lawmakers are beginning to see the physical mechanisms underlying pain and humans' experience of it, expanding plaintiffs' ability to seek redress for genuine injuries through tort law.[64] Though the experience of pain and emotion is inherently subjective, this technology can help expose and quantify harms in ways we have not seen before. Furthermore, preventing the worsening of an injury by detecting it at its earlier stages may reduce individual medical treatment costs and curb future litigation.

The next part of this Note will argue why there is inherent value in using this technology to help litigants demonstrate their invisible injuries and finally receive legal recognition.

II. NEUROLAW'S POTENTIAL TO ADVANCE HUMAN RIGHTS IN TORT CASES

This Part describes how neuroscience technology can be used to advance human and civil rights, particularly in the context of tort law. Section A describes the current state of tort standards, and Section B describes how neuroscience is already being presented in courtrooms regarding detection of pain. Sections C, D, and E then explain how neuroscience technology may be useful in helping plaintiffs receive compensation for other invisible injuries, focusing on case studies of emotional distress and PTSD, concussions, and neurotoxicity.

A. Tort Law and the Decline of Substance Dualism

Tort law serves a variety of purposes in society, providing compensation, insurance, and deterrence through an economic model in which those who have caused harm monetarily compensate those

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63. Two exceptions to the physical-emotional distinction are intentional infliction of emotional distress and negligent infliction of emotional distress, which apply only in rare circumstances, although their allowance has expanded over time and varies by jurisdiction. *See* RESTATEMENT (THIRD) OF TORTS: LIABILITY FOR PHYSICAL & EMOTIONAL HARM §§ 46, 47 (AM. LAW INST. 2012).

64. "I am confident that we will soon be able to predict, with a high degree of accuracy, some neurological and mental illnesses. Then we will have to answer the question, 'What do we do now?'" Henry T. Greely, Keynote Address, *Law and the Revolution in Neuroscience: An Early Look at the Field*, 42 AKRON L. REV. 687, 691 (2009).

who have been injured.[65] But what counts as "harm" is not always straightforward. In the United States, "physical" harm has traditionally been distinguished from "mental" harm in tort suits, and courts are much more likely to award damages for physical injuries than for emotional and invisible injuries, largely because the latter two have traditionally been difficult to prove.[66] Relatedly, courts are worried about malingering litigants and are fearful that allowing compensation for less outwardly verifiable injuries could bring a flood of cases that would absorb "resources better left available to those more seriously harmed."[67] Whether it is in statutory law generated by legislatures, common law interpreted by courts, or insurance contracts agreed to between private parties, the law consistently makes this physical-mental distinction.

The theory that mental experiences are something wholly different from bodily ones is known as "substance dualism." Implicit in substance dualism is a societal belief that claims of emotional or mental harm are less deserving of compensation than those with physical consequences.[68] International institutions[69] and American

65. Courts grant compensatory damages for things such as lost wages, medical costs, and loss of earning potential to restore an injured party to his preinjury position. Tort compensation may also "serve an expressive or symbolic function, demonstrating that harming others is a wrongful act that causes dignitary harm beyond the physical and emotional damages." Rick Swedloff & Peter H. Huang, *Tort Damages and the New Science of Happiness*, 85 IND. L.J. 553, 588 (2010).

66. RESTATEMENT (THIRD) OF TORTS: LIABILITY FOR PHYSICAL & EMOTIONAL HARM § 47 (AM. LAW INST. 2012). Many insurance policies, criminal statutes, and government immunity statutes also have a mental-bodily distinction. Francis X. Shen, *Monetizing Memory Science: Neuroscience and the Future of PTSD Litigation*, *in* MEMORY AND LAW 325–26 (Lynn Nadel & Walter P. Sinnott-Armstrong eds., 2012).

67. Metro-North Commuter Railroad Co. v. Buckley, 521 U.S. 424, 442 (1997).

68. Comments to the Restatement of the Law (Third) of Torts explain the reasoning behind the distinction: "emotional distress is less objectively verifiable than physical harm and therefore easier for an individual to feign, to exaggerate or to engage in self deception about the existence or extent of the harm." Advances in neuroscience may call this distinction into question as harms such as emotional distress are shown to have a physiological basis. RESTATEMENT (THIRD) OF TORTS (AM. LAW INST. 2012).

69. Notably, the Office of the United Nations High Commissioner for Human Rights recognizes the obligation of states "to protect against [emotional] harm by third parties, including the private sector. . . ." *See Report of the Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health* § 41, U.N. Doc. A/HRC/35/21 (March 28, 2017); *see also*

courts, to varying degrees, have recognized that tortfeasors should be held responsible for causing emotional distress injuries such as anxiety, loss of tranquility, loss of autonomy, and diminished enjoyment, but have treated these proffered injuries as "second class citizens."[70] Yet nearly all brain researchers and philosophers reject substance dualism in favor of monism, the view that "conscious experience is inseparable from the physical brain."[71] Insights from neuroscience, psychology, and psychiatry have exposed dualism as "empirically flawed and conceptually bankrupt . . . a person cannot be reduced to his mind or separated from his body. He is, inescapably, both at once."[72]

The physical-mental bifurcation in tort law does not sufficiently take into account modern developments in the understanding, diagnosis, and verification of illnesses and trauma that affect brain structure and function.[73] This distinction assumes that medical professionals cannot identify the underlying biological bases of most psychiatric disorders, as opposed to the more discernible pain of an outwardly obvious injury like a broken leg. As we continue to discover the physiological origins of emotional harm through

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Lisa J. Laplante, *Human Torts*, 39 CARDOZO L. REV. 245, 247 (2017) (arguing that emotional distress suits can "be reframed as violations of the most basic human rights such as the right to physical and mental integrity under international human rights law, grounded in treaty and international customary law").

70. Grey, *supra* note 58, at 2605–08.

71. JAMES W. KALAT, INTRODUCTION TO PSYCHOLOGY 6 (9th ed. 2010). As a "learned author" quoted by Judge Clark in Young v. W. Union Tel. Co. puts it, "the mind is no less a part of the person than the body, and the sufferings of the former are sometimes more acute and lasting than those of the latter." 107 N.C. 370, 385, 11 S.E. 1044, 1048 (1890).

72. Dov Fox & Alex Stein, *Dualism and Doctrine*, 90 IND. L.J. 975, 975–1010 (2015).

73. Scientists and scholars are moving away from treating "mental" and "physical" as separate categories. *See* Peter A. Alces, THE MORAL CONFLICT OF LAW AND NEUROSCIENCE 131–32 (University of Chicago ed., 2018) ("Once we have a way to 'see' emotional injury as clearly as we can 'see' a broken bone . . . there would be no reason to maintain the tort law's distinction between physical and emotional injury."); *see also* Govind Persad, *Law, Science, and the Injured Mind*, 67 ALA. L. REV. 1179, 1215–16 (2016) ("Our improved understanding of the biological correlates of mind-dependent harms suggests that the line between 'body' and 'mind' is no longer sufficient to support the differential legal treatment of these harms.").

brain imaging evidence,[74] the distinction becomes outmoded.[75] As advancements in neuroscience grant us greater ability to quantify emotional harm claims, tort litigants may be able to introduce neuroimaging evidence as objective proof of injury, and courts and legislatures should begin to see emotional injuries' capacity to harm litigants and rethink this anachronistic distinction.[76] Many of these litigants are members of populations that are underprivileged or that have historically been undercompensated in their legal rights.[77] If neuroscience technology continues to be increasingly precise and reliable, then many litigants whom have suffered trauma that has

74. *See* Joseph E. LeDoux, *Emotional Circuits in the Brain*, 23 ANN. REV. NEUROSCIENCE 155, 156 (2000).

75. *See* Betsy Grey, *Implications of Neuroscience Advances in Tort Law: A General Overview,* 12 IND. HEALTH L. REV. 671, 689–90 (2015) (arguing that distinctions between emotional and physical pain are false because of the changes in the brain that result from emotional pain). The court's analysis in Allen v. Bloomfield Hills School District, 760 N.W.2d 811 (Mich. Ct. App. 2008), may signal the beginning in rethinking the physical-emotional divide. Allen, diagnosed with PTSD stemming from an accident in which he suffered no bodily injuries, submitted a PET scan of his brain depicting abnormal decreases in frontal and subcortical activity which the Court of Appeals said represented "objective medical evidence that a mental or emotional trauma can indeed result in physical changes to the brain" and found that "[t]he brain is a part of the human body, so 'harm or damage done or sustained' is injury to the brain and within the common meaning of 'bodily injury' in MCL 691.1405 . . . . What matters for a legal analysis is the existence of a manifest, objectively measured injury to the brain." *Allen,* 760 N.W.2d at 815. *See also* Pekin Ins. Co. v. Hugh, 501 N.W.2d 508, 512 (Iowa 1993) (finding that whether a claimant suffered "bodily injury" involved "a medical or psychological problem of proof rather than purely a question of law . . . . [Compensation] should not therefore turn on any artificial and arbitrary classification such as 'physical' or 'psychological'"). The distinction is also losing traction in the international sphere: The Supreme Court of New South Wales ruled that a woman who experienced PTSD as the result of an airplane crash could recover damages under the Montreal Convention because it deemed PTSD was in and of itself "bodily injury," unlike previous rulings under the international agreement. Victoria Gallanders, *Australia: Post Traumatic Stress Disorder (PTSD) ruled as bodily injury in landmark case*, MONDAQ (July 7, 2015), http://www.mondaq.com/australia/x/410418/Personal+Injury/Post+Traumatic+Stress+Disorder+PTSD+ruled+as+bodily+injury+in+landmark+case [https://perma.cc/N3N6-VGTW].

76. AM. PSYCHIATRIC ASS'N, DIAGNOSTIC AND STATISTICAL MANUAL OF MENTAL DISORDERS (5th ed. 2013) (incorporating a broadened view of mental injury as a result of these neuroscientific advances).

77. For example, neuroscience can help inform administrators about the emotional impact of solitary confinement on prisoners and the emotional effect of prison violence, which could lead to a more rehabilitative and effective criminal justice system. *See* Gertner, *supra* note 10, at 544–46.

otherwise been overlooked by the legal system may at least be able to get their day in court.

Indeed, neuroscience research has begun to shed light on the specific neural correlates of emotional pain, proffering concrete evidence that these injuries may not be so second-class. Individuals with emotional trauma or psychiatric disorders have abnormalities in a number of brain regions, including the adrenal systems, the amygdala, the hippocampus, and the cortices, and exposure to traumatic events can change this circuitry in previously healthy individuals.[78] Studies have confirmed that, in certain instances, pugnacious words or tones, verbal threats, bullying, or emotional abuse can cause neurochemical changes in the amygdala and atrophy in prefrontal cortical function.[79] This can influence students' ability to perform in school and affect an individual's likelihood of future disease or even one's lifespan.[80] fMRI scans show that emotional pain physically affects the same brain area as bodily injuries and that emotional harm can be at least as painful as physical harm.[81] Emotional pain can also be more prolonged or more debilitating than physical pain.[82]

As diagnostic imaging techniques are increasingly able to provide more objective evidence of these kinds of brain-based distress, there is less justification for entrenched laws and policy that make it harder to recover for invisible injuries than physical ones.[83] Limiting

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78. Martin P. Paulus, *The Role of Neuroimaging for the Diagnosis and Treatment of Anxiety Disorders*, 25 DEPRESSION & ANXIETY 348, 350 (2008). Neuroimaging has found that subregions of the limbic system, the cortices, the amygdala, and the hippocampus are involved in the processing of emotional trauma. Research suggests that dysfunction in this circuitry triggers and maintains emotional disorders.

79. *Id.*

80. *See, e.g.*, Jennifer Knack et al., *Worse than Sticks and Stones? Bullying is Linked with Altered HPA Axis Functioning and Poorer Health*, 77 BRAIN & COGNITION 183, 183 (2011) (finding that peer victimization may be linked to poor physical health as displayed by particular neuroendocrine functions in a group of adolescents).

81. Naomi I. Eisenberger, *Broken Hearts and Broken Bones: A Neural Perspective on the Similarities Between Social and Physical Pain*, 21 CURRENT DIRECTIONS PSYCHOL. SCI. 42, 45 (2012) (noting "experiences of social and physical pain actually rely on some of the same neurobiological and neural substrates").

82. *Id.* Neuropsychological evidence shows that "emotional harm can be longer lasting than physical harm" because one can "relive the experience of the emotional pain and feel it again." *Id.*

83. Adam J. Kolber, *The Experiential Future of the Law*, 60 EMORY L.J. 585, 585 (2011) (averring that technological advances in neuroscience "will improve our

tort claims to outwardly visible injuries fails to recognize the progress that our society has made in understanding mental health matters and that non-visible injuries can be as real and debilitating as visible ones.[84] How neuroscientific evidence is used in courtrooms and translated into policy may thus have significant ramifications for civil recovery, especially for those litigants who have been effectively disparaged because they had no objective evidence to substantiate their claims.[85] At the very least, the increased ability to detect and quantify emotional pain should force courts and legislators to reexamine this divide. The following are examples of ways that neuroscience can help detect evidence of invisible injuries and preserve the deterrent and corrective justice functions of civil law, particularly in the field of torts.

B. Neuroscience and the Identification of Pain

One area of civil litigation in which neuroscience increasingly plays a role is in the determination and valuation of pain. About $150 billion[86] and hundreds of thousands of legal proceedings each year[87] in

assessments of physical pain, emotional distress, and a variety of psychiatric disorders" that are largely subjective experiences).

84. AM. PSYCHIATRIC ASS'N, DIAGNOSTIC AND STATISTICAL MANUAL OF MENTAL DISORDERS xxx (4th ed. text rev. 2000) (stating "the term mental disorder unfortunately implies a distinction between 'mental' disorders and 'physical' disorders that is a reductionistic anachronism of mind/body dualism. A compelling literature documents that there is much 'physical' in 'mental' disorders and much 'mental' in 'physical' disorders"). Judge Totenberg referenced this passage in her decision in Reid v. Metro. Life Ins. Co., 944 F. Supp. 2d 1279, 1305 (N.D. Ga. 2013).

85. Mark Anderson, who served as a mental health policy advisor in the Senate, stated that "a health care system that does not treat the brain with the body is outmoded." Francis X. Shen, *Mind, Body, and the Criminal Law*, 97 MINN. L. REV. 2036, 2061 (2013). This has gained some traction at least in the health law sphere as there has been a sustained movement to enact mental health parity laws that recognize "biologically based mental illness." *Id.* at 2060; *see also* Reid, 944 F. Supp. 2d at 1323, in which a plaintiff used neuroscientific data to demonstrate that her diagnosis of dementia is based in physical processes in order to receive longer-term disability benefits. Judge Totenberg placed great weight on an MRI of Ms. Reid's brain, stating that Ms. Reid's dementia was "confirmed by her neuroimaging results showing cerebral atrophy," and that MetLife's failure to consider the MRI as evidence of dementia was arbitrary and capricious. *Id.*

86. Irene Tracey & M. Catherine Bushell, *How Neuroimaging Studies Have Challenged Us to Rethink: Is Chronic Pain a Disease*?, 10 J. PAIN 1113, 1114 (2009).

87. Adam Kolber estimates that pain is an issue in about half of all tort cases. Greg Miller, *Brain Scans of Pain Raise Questions for the Law*, 323 SCI. 195, 195 (2009).

the United States turn on the existence and extent[88] of a litigant's pain, often in disability, insurance, product liability, medical malpractice, workers' compensation, personal injury, and pain and suffering[89] proceedings. Yet, evaluation of pain largely depends on subjective self-reporting that can frequently be difficult to express, relatively easy to exaggerate, and hard for others to understand.[90]

Neuroscience may be able to corroborate a person's described experience of pain or provide evidence about pain for those who are unable to verbally communicate, such as infants or the unconscious. The use of brain imaging technology can demonstrate where in the brain litigants' self-reported pain correlates with neural activity and how particular pain conditions result in the reshaping of certain brain structures and neural circuitry.[91] Researchers have found, for example, that chronic headaches, back pain, and phantom limb pain are associated with decreased grey matter density in the prefrontal cortex and thalamus of the brain.[92] Scholars have advocated that neuroimaging of chronic pain should lead to modifications of mental

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88. Amanda C. Pustilnik, *Pain as Fact and Heuristic: How Pain Neuroimaging Illuminates Moral Dimensions of Law*, 97 CORNELL L. REV. 801, 801 (2012) ("Important legal distinctions turn on the presence and degree of physical pain. [For example, some] statutes refer to degrees of physical pain to define criminal offenses like torture-murder, while pain that rises to the level of cruelty draws the boundary between constitutionally permissible and impermissible punishment.").

89. "Pain and suffering" includes fright, nervousness, grief, anxiety, worry, mortification, shock, humiliation, indignity, embarrassment, apprehension, terror or loss of enjoyment of life that a tort victim suffers because of the civil wrongdoing of another. Adam J. Kolber, *Pain Detection and the Privacy of Subjective Experience*, 33 AM. J.L. & MED. 433, 441 (2007).

90. "[P]ain is largely invisible, unquantifiable, and often grossly misunderstood, leading to unnecessary suffering on the part of people whose pain is not credited and to unnecessary expense when the legal and medical systems function inefficiently or the wrong claimants are compensated." Amanda C. Pustilnik, *Painful Disparities, Painful Realities* 3 (U. Md. Legal Stud. Res. Paper No. 2014-18, 2014).

91. *Id.* at 4.

92. A. Vania Apkarian et al., *Chronic Back Pain Is Associated with Decreased Pre-frontal and Thalamic Gray Matter Density*, 24 J. NEUROSCI. 10410, 10412 (2004). PET, electroencephalography, and fMRI scans have shown that the cortical and subcortical regions, regions responsible for handling sensory perceptions, activate during pain stimulation and are referred to as the "pain matrix." Parts of these regions can discern the location and intensity of painful stimuli while others are involved in the experiential and perceiving aspect of pain. Tor D. Wager et al., *An fMRI-Based Neurologic Signature of Physical Pain*, 368 NEW ENG. J. MED. 1388, 1388 (2013).

and physical disability regulations as well as workers' compensation regimes.[93]

Although technology has allowed researchers to discover structures of the brain that are responsible for pain perception, whether this is enough to prove pain and suffering in court is more tenuous, especially under the *Daubert* and *Frye* standards[94] for the admission of expert evidence.[95] Expert opinions diverge on whether neuroimaging technology's ability to determine precise levels of pain is reliable enough for courtroom use. Some argue that many external factors affect an individual's pain perception[96] and that sensitivity to pain varies significantly from one individual to another. Professor Amanda Pustilnik believes that aggregate pain neuroimaging evidence ought to be admissible under the federal, state, and administrative evidence regimes for limited purposes, but that brain scanning technology is not, or at least not yet, a "fraud-o-meter, pain-o-meter, or mind-reading machine;" it is better used as a tool for increasing understanding about these complex phenomena and for educating judges and jurors.[97] A number of private entities,[98] scientists,[99] and

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93. *See generally* Kolber, *supra* note 83, at 587 (noting that technological advances in neuroscience will improve assessments of physical pain, emotional distress, and psychiatric disorders that are subjective experiences) and Tovino, *supra* note 44, 697–727 (exploring role that brain scanning technologies play in health insurance coverage, social security eligibility and recognizing gender-specific mental health conditions).

94. *See supra* note 30 (defining the *Daubert* and *Frye* standards).

95. It is also important to note that a majority of pain-related claims are heard in administrative settings for matters such as workers' compensation and disability claims, in which the "rules of evidence are slacker, and in some cases close to non-existent, and there is no jury, and there are no instructions." David Seminowicz et al., *Panel 1: Legal and Neuroscientific Perspectives on Chronic Pain,* 18 J. HEALTH CARE L. & POL'Y 207, 225 (2015). Administrative law judges are not bound by *Daubert* and can be crucial decision makers in applying the law relative to evidence of chronic pain. *Id.* at 226.

96. Psychological factors including anxiety, attention, and distractions may alter signals in fMRIs. Miller, *supra* note 87, at 195.

97. Pustilnik, *supra* note 88, at 6.

98. A number of private companies, such as Connecticut-based company Millennium Magnetic Technologies, offer brain scanning services for litigants to validate the presence of pain. *See Use of Functional MRI to Validate the Presence of Pain*, MMT NEUROTECH, www.milmag.net/document-pain [https://perma.cc/6VSP-JUVL].

99. Studies by neuroscientists such as Tor Wager at the University of Colorado and Sean Mackey at Stanford University have also determined, at least in controlled experiments, that fMRIs were able to determine with 80% accuracy whether or not a particular subject is in pain. Sara Reardon, *Neuroscience in Court: The Painful Truth*, 518 NATURE 474, 475 (2015).

courts[100] have taken more lenient views, and the use of pain-scanning techniques for tort litigation has risen.[101]

fMRI pain scans may not meet the requisite level of certainty to make them useful in all cases. Even so, the reliability of the technology has increased markedly in a very short period of time. While today's neuroscience has not yet produced a foolproof "pain-o-meter," it can map brain pathways and offer increasingly tailored treatment, explanation, and measurement of pain in individuals.[102] It "now shows that distinct chronic pain conditions produce characteristic patterns of structural brain alteration, with the degree of visible brain alteration correlating with the duration, severity, and type of chronic pain,"[103] which can offer some visibility to litigants' previously discounted claims of pain.

C. Neuroscience and PTSD

Cases involving PTSD illustrate how broken the physical-mental division in tort law is.[104] Neuroscience research has begun to document structural changes to the brains of PTSD-diagnosed participants by showing how PTSD results from disrupted circuitry between the amygdala, the brain region stimulated when an individual experiences stress or trauma, the hippocampus,[105] which plays a

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100. Carl Koch, whose wrist was burned by molten asphalt, sued his former employer for damages for his chronic pain over a year after the burn. Judge Chon-Lopez admitted Koch's brain scan indicating his pain. *Id.* The case ultimately settled for $800,000. *Id.*

101. *Id.*

102. Karen D. Davis et al., *Brain Imaging Tests for Chronic Pain: Medical, Legal and Ethical Issues and Recommendations*, 13 NATURE REV. NEUROLOGY 624, 634 (2017) (asserting that "[neuroscience] research can guide the crafting of more accurate and precise laws that relate to pain as a source of disability, and can assist the evaluation of evidence in individual cases").

103. Pustilnik, *supra* note 30, at 1117.

104. Since its official recognition in 1980 by the American Psychiatric Association, PTSD has become prevalent in much personal injury litigation. From 1999 to 2004, there was nearly an 80% increase in PTSD cases, with payments reaching over $4 billion, and those numbers have continued to expand. Harvard professor Alan Stone has remarked that "no diagnosis in the history of American psychiatry has had a more dramatic and pervasive impact on law and social justice than . . . PTSD." Shen, *supra* note 85, at 2159 (footnote omitted).

105. Research has shown that stress impairs the hippocampus's capacity to regenerate neurons as part of its normal functioning. Studies of children with PTSD in particular have found that these impairments can lead to problems with learning, memory, and academic achievement. CHILD WELFARE, UNDERSTANDING THE EFFECTS OF MALTREATMENT ON BRAIN DEVELOPMENT 8–9 (2015),

central role in the formation of memory, and the pre-frontal cortex, which regulates emotional responses to fear and stress. Neuroscientists have found that PTSD can also cause disruption of neurotransmitter networks such as the noradrenergic system, the serotonergic system, and the hypothalamic-pituitary-adrenal axis.[106]

Many types of psychological trauma can cause PTSD, such as car accidents, military combat, childhood abuse, rape, and assault.[107] Patients with PTSD can suffer from a wide array of symptoms that reflect stress-induced changes in neurobiological systems, including "intrusive memories, flashbacks, hyper-vigilance, sleep disturbance, avoidance of traumatic stimuli, physiological hyperresponsivity, numbing of emotions, and social dysfunction."[108] While such symptoms are commonly understood to be psychological problems, some or all of them may well be related to the physical effects of extreme stress on the brain resulting from a dysfunction of the neural networks that regulate memory and fear.

Neuroscience evidence can play a critical role in determining whether PTSD is understood as a mental or a bodily injury, the latter of which is often required for plaintiffs to recover damages in tort claims as well as in insurance policies, contracts, or claims against the government. To receive damage awards in PTSD litigation, a plaintiff must establish the existence of PTSD as well as specific causation between the defendant's actions and that injury. Neuroscience findings can help fortify that chain.[109] Documenting real-time neurochemical changes can help clarify that there is at least some physical damage that correlates with PTSD in an individual. These advances might be particularly salient for victims of domestic violence as medical professionals are becoming increasingly cognizant of the neurobiological consequences of battering.[110] Furthermore, while

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https://www.childwelfare.gov/pubPDFs/brain_development.pdf [https://perma.cc/6KGN-Y6UH].

106. PTSD "causes significant changes in brain chemistry, brain function, and brain structure. The brain becomes 'rewired' to over-respond to circumstances that are similar to the traumatic experience." Allen v. Bloomfield Hills Sch. Dist., 760 N.W.2d 815, 816 (Mich. Ct. App. 2008) (footnote omitted).

107. V. Francati et al., *Functional Neuroimaging Studies in Posttraumatic Stress Disorder: Review of Current Methods and Findings*, 24 DEPRESSION & ANXIETY 202, 202 (2007).

108. *Id.*

109. Shen, *supra* note 66, at 332.

110. *See generally* Jozsef Meszaros, *Achieving Peace of Mind: The Benefits of Neurobiological Evidence for Battered Women Defendants*, 23 YALE J.L. &

society might consider military veterans or victims of domestic violence to be "deserving victims" of compensation for PTSD, what about victims of PTSD triggered by their imprisonment or participation in gang violence?[111] Should social disapproval of these stressors allow the criminal justice system to withhold sentencing mitigation of these defendants even though they too suffer from PTSD? Neuroscience can offer credence to the claims of such victims and to people of all backgrounds, regardless of their status in society.

This increasingly substantial research suggests that maybe it is time to stop disfavoring tort liability for emotional distress, or at least reconsider it for particularly vulnerable populations.[112] The capacity of functional neuroimaging to identify the biological correlates of emotional experience makes it clear that being subjected to stress or abuse can lead to objectively identifiable changes in the brain and can play a role in substantiating subjectively reported pain. We must critically examine and clarify the normative foundations for the distinctions we have historically taken for granted.[113] If dualism is outmoded, how might we, and should we, distinguish mental and psychological torts from other types of torts?[114] While a bright line

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FEMINISM 117 (2011) (describing how neurobiological evidence can provide insight into the effects of battering, at both an individual and ecological level).

111. This issue has come up in international settings as well. In a 1998 trial of a Bosnian-Croatian soldier, experts for both the defense and the prosecution relied on neuroscientific evidence to argue whether a torture victim was suffering from PTSD. Shen, *supra* note 66, at 333.

112. Vulnerable populations might include those that have traditionally had limited access to courts or have been relatively neglected; they might include persons of lower economic backgrounds, racial, gender, or ethnic minorities, or those in overlooked areas of society. Prisoners, for example, are potentially given less credence in courtrooms than other citizens: the Prison Litigation Reform Act prohibits prisoners from suing for emotional injury without being able to show physical injury or sexual misconduct. 42 U.S.C. § 1997e (2012). *See also* Persad, *supra* note 73, at 1199 (discussing how U.S. courts tax the damages victims of emotional injury receive, while leaving damages for physical injury untaxed).

113. Betsy Grey, *Neuroscience and Emotional Harm in Tort Law: Rethinking the American Approach to Free-Standing Emotional Distress Claims*, *in* 13 LAW & NEUROSCIENCE: CURRENT LEGAL ISSUES 203, 225 (Michael Freeman ed., 2011) (arguing that "the availability of neuroimaging evidence should argue in favor of abandoning the more artificial and arbitrary tests for limiting emotional harm claims such as physical impact, physical manifestation and zone of danger").

114. Cass Sunstein proposes, for example, that we differentiate injuries along a permanent-temporary divide, rather than a mind-dependent-mind-independent divide. Cass R. Sunstein, *Illusory Losses*, 37 J. LEGAL STUD. 157, 163 (2008).

might be necessary, the physical-mental distinction may no longer be the most appropriate point on which to divide it.

D. Neuroscience's Potential to Identify Mild Traumatic Brain Injury

Litigation and national public health concerns over mild Traumatic Brain Injury (mTBI) and Traumatic Brain Injury (TBI)[115] have gained prominence as reliance on brain scanning has increased.[116] The terms "concussion" and "mTBI" are often used interchangeably. mTBI currently stands as a subjective clinical diagnosis based primarily on patient history and observable behavioral symptoms, which may include concussions and loss of consciousness, confusion,

115. Traumatic brain injury occurs when an external force or impact causes damage to the brain, which can result in chemical changes in nerve cells, mechanical disruption of axons, changes in brain blood flow, and neuro-inflammation. Thomas W. McAllister, *Neurobiological consequences of traumatic brain injury*, DIALOGUES IN CLINICAL NEUROSCIENCE (2011), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3182015/ [http://perma.cc/XDG5-7E8L].

116. Betsy J. Grey and Gary E. Marchant claim that the United States is currently facing a "concussion epidemic." Betsy J. Grey & Gary E. Marchant, *Biomarkers, Concussions, and the Duty of Care*, 2015 MICH. ST. L. REV. 1911, 1911 (2015). This is evident in the more than 5,000 former National Football League (NFL) players suing the NFL, claiming it failed to take reasonable steps to protect them from concussive brain injuries and that it concealed the long-term risks associated with concussion. *See* In re Nat'l Football League Players Concussion Injury Litig., 821 F.3d 410, 423 (3d Cir. 2016). The National Collegiate Athletic Association, the National Hockey League, Federation Internationale de Football Association, World Wrestling Entertainment, and even high schools are all currently embroiled in lawsuits involving athletes' head injuries. *See* In re Nat'l Collegiate Athletic Ass'n Student-Athlete Concussion Injury Litig., 314 F.R.D. 580, 583 (N.D. Ill. 2016); In re Nat'l Hockey League Players' Concussion Injury Litig., 189 F. Supp. 3d 856, 860 (D. Minn. 2016); Mehr v. Féderation Internationale De Football Ass'n, 115 F. Supp. 3d 1035, 1043 (N.D. Cal. 2015); Haynes v. World Wrestling Entm't Inc., 2015 WL 3905281, at *1 (D. Or. June 26, 2015); Bukal v. Illinois High School Ass'n, No. 2014-CH-19131 (Cook Cty. Cir. Ct., Ill., Dec. 1, 2014). As of 2018, researchers have discovered chronic traumatic encephalopathy (CTE) in more than 100 former NFL players, a handful of whom have committed suicide. Adam Kilgore, *Aaron Hernandez suffered the most severe case of CTE ever discovered in a person his age,* WASH. POST (Nov. 9, 2017), https://www.washingtonpost.com/sports/aaron-hernandez-suffered-from-most-severe-cte-ever-found-in-a-person-his-age/2017/11/09/fa7cd204-c57b-11e7-afe9-4f60b5a6c4a0_story.html [https://perma.cc/F6GP-S7C9]; Jesse Mez, Daniel H. Daneshvar and Patrick T. Kiernan, *Clinicopathological Evaluation of Chronic Traumatic Encephalopathy in Players of American Football*, JAMA 318(4), 360–370 (2017).

dizziness, fatigue, nausea, and trouble with learning and memory.[117] Sometimes symptoms might endure for weeks or longer, manifesting in persistent headaches, sleep disturbance, poor concentration, irritability, and depression.[118] The Centers for Disease Control and Prevention estimates that, in the United States, 1.7 million people suffer a TBI each year, and it is likely that many more go unreported.[119] With an estimated total cost to society exceeding $76 billion per year, the epidemic has far-reaching consequences.[120]

Unfortunately, because mTBI manifests in no particular physically distinct way, there is presently a lack of unequivocal metrics to detect it.[121] Thus, the millions of professional and youth athletes, as well as victims of head trauma in transportation accidents, military combat,[122] domestic abuse, and workplace injuries, can find tort claims difficult to prove in court.[123] This is especially so when debilitating symptoms, which can be extremely severe in some cases,[124] do not

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117. Richard P. Dutton et al., *Diagnosing Mild Traumatic Brain Injury: Where Are We Now?*, 70 J. TRAUMA 554, 554 (2011).

118. *Id.*

119. CTRS. FOR DISEASE CONTROL & PREVENTION, GET THE STATS ON TRAUMATIC BRAIN INJURY IN THE UNITED STATES, https://www.cdc.gov/traumaticbraininjury/pdf/bluebook_factsheet-a.pdf [https://perma.cc/2YHD-7HYC].

120. *Severe TBI*, CTRS. FOR DISEASE CONTROL & PREVENTION, http://www.cdc.gov/TraumaticBrainInjury/severe.html [https://perma.cc/6NWB-9774].

121. "[m]TBIs often do not show up on . . . CT . . . or MRI [scans], since the injuries are typically not structural injuries to the brain, but rather, are functional problems caused by swelling or bruising." Grey & Marchant, *supra* note 116, at 1924. Neuroscientist Michael Selzer has said that "cognitive deficits can be subtle, even to a neurologist." Emily Singer, *Detecting Subtle Brain Injuries*, MIT TECH. REV. (Nov. 18, 2008), https://www.technologyreview.com/s/411201/detecting-subtle-brain-injuries/ [https://perma.cc/LMX7-PGKJ].

122. *See* Megan Osborn, *Healing the Invisible: How the VA Fails to Adequately Compensate Veterans for Mild Traumatic Brain Injury*, 26 FED. CIR. B.J. 379, 384–85 (2017).

123. *See* Boyd v. Bert Bell/Pete Rozelle NFL Players Ret. Plan, 410 F.3d 1173, 1177 (9th Cir. 2005) (noting that Boyd's SPECT scan revealed decreased brain activity consistent with head trauma and was admitted into court under *Daubert*, but the physician for the defense claimed that, based on this evidence, the head injury in question "could not be organically responsible for all or even a major portion of the neurologic and/or neuropsychologic problems that Mr. Boyd is experiencing now, to a reasonable degree of medical probability"). As neuroscience imaging becomes more precise, however, this type of evidence may help plaintiffs with similar injuries in the future.

124. The estate of former NFL player Aaron Hernandez filed a lawsuit against the New England Patriots and the NFL, claiming that Hernandez's injuries and death were a direct result of his participation in football and that the Patriots

manifest immediately. For those that suffer from chronic traumatic encephalopathy (CTE), their diagnosis and resulting redress may come too late.[125]

Over the past few years, however, neuroscientific research has begun to develop more nuanced, objective diagnostic measures[126] of mTBIs by, for instance, evaluating levels of proteins that regulate cell development and degradation and act as an indicator of TBI.[127] Neuroscientists also scan eye movements of patients to detect signs of mTBI via magnetoencephalography, a functional brain imaging technique that measures neuronal currents. A variety of other neuroimaging techniques are also being investigated for providing biomarkers of mTBI.[128] In the fall of 2017, a group of researchers at Boston University discovered a possible means of detecting CTE in

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knew hits to the head could lead to brain damage and failed to protect him. *See* Nathan Fenno, *Disgraced ex-Patriots player Aaron Hernandez found to have CTE and early brain atrophy*, L.A. TIMES (Sep. 21, 2017), http://www.latimes.com/sports/sportsnow/la-sp-aaron-hernandez-cte-20170921-story.html [https://perma.cc/7DXG-8LYC]. Similarly, Chris Benoit, a professional WWE wrestler who murdered his wife and seven-year-old son and then hanged himself, was found to have a brain that was "severely damaged and, like an Alzheimer's patient, [riddled] with aggregates of a neural protein called tau . . . consistent with severe [CTE]." Grey & Marchant, *supra* note 116, at 1914.

125. Symptoms of CTE, which include memory loss, depression, suicidal thoughts, and aggressive behavior, have been noted in ice hockey players, soccer players, boxers, and football players, among others. CTE symptoms in the brain reflect those found in Alzheimer's patients and can take years or even decades after the brain trauma has occurred to manifest. CTE currently can be diagnosed definitively only through autopsy. Grey & Marchant, *supra* note 116, at 1914–15, 1918.

126. These include MRIs, diffusion tensor imaging, magnetization transfer ratio, susceptibility weighted imaging, myelin water imaging, ultrashort echo time, and proton magnetic resonance spectroscopy that detects white matter injury. Ponnada A Narayana, *White matter changes in patients with mild traumatic brain injury: MRI perspective*, 2 CONCUSSION 2 (2017).

127. Grey & Marchant, *supra* note 116, at 1937.

128. *Id.* at 1936. Researchers used PET scans after injecting a radioactive tracer that binds to deposits of tau, a protein secreted by the axons of unmyelinated nerve cells when they are injured. Using these PET scans, the researchers were able to pinpoint where in the brain these abnormal proteins accumulated and identify distinctive patterns of tau tangles in the amygdala and subcortical regions of the former football players that did not appear in the normal brains of the study's controls. Other studies have used S100B and glial fibrillary acidic protein and found that increased levels of SNTF, a protein that increases in the blood after some concussions, were strongly correlated with diffuse axonal injury and long-term cognitive dysfunction.

living plaintiffs;[129] studies are increasingly finding that diffusion tensor imaging may also be useful in detecting mTBI.[130] This is one example of an advancement in neuroscience enabling a far larger class of plaintiffs to litigate. These methods are in their infancy, however, and more studies are needed before they can be used as definitive ways to diagnose mTBI, TBI, and CTE in living patients.

As the science improves, more precise brain scans may significantly inform courts and policymakers as they wrestle with complex questions regarding the nature of concussive injury, the need for regulation in the area, and the allocation of fault and duties with regard to head injuries. Indeed, all fifty states now have legislation to prevent concussions and to limit further injury to student-athletes who sustain concussions.[131] Moreover, with increasingly accurate brain scanning technology, more claims may be made in professional malpractice lawsuits and in negligence claims against entities sponsoring athletic events. Plaintiffs may also pursue latent injury claims,[132] which have been causally difficult to substantiate. These developments might also prompt courts to hold coaches, trainers, and parents to a higher standard of care. The findings will help scientists better define the type of damage that can lead to long-lasting memory and emotional problems, as well as help identify those who are most vulnerable to further trauma.

Ultimately, neuroscience will inform the debate as to what risks are acceptable for whom, and it will allow individuals to better understand how their brains have been affected. It will also prompt more just compensation, especially considering the coercive social and economic pressures to underreport symptoms or to ignore the risks of

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129. Maggie Fox, *Test Might Diagnose Brain Damage in Living Football Players*, NBC NEWS (Sep. 27, 2017), https://www.nbcnews.com/health/health-news/test-might-diagnose-brain-damage-living-football-players-n804916 [https://perma.cc/D7JQ-QUXW]. *See also* Bennet Omalu et al., *Postmortem Autopsy-Confirmation of Antemortem [F-18]FDDNP-PET Scans in a Football Player with Chronic Traumatic Encephalopathy*, 82 NEUROSURGERY 237, 237 (2018) (identifying a modality that could allow for definitive diagnosis of CTE in living patients based on brain autopsies).

130. Martha E. Shenton et al., *Mild Traumatic Brain Injury: Is DTI Ready for the Courtroom?*, 61 INT'L J.L. & PSYCHIATRY 50, 50–63 (2018).

131. Grey & Marchant, *supra* note 116, at 1946.

132. "Latent injury claims permit a claimant to receive compensation before a serious disease has manifested." *Id.* at 1958.

these activities,[133] which are often inevitably linked to issues of social and racial justice.[134]

E. Neuroscience's Potential to Identify Neurotoxins in the Brain and Nervous System

Exposure to toxins can cause neurophysiological changes in the brain, which can lead to cognitive impairment, neurodegenerative diseases, or the onset of psychiatric disorders such as ADHD or autism—even though these effects are typically invisible to the naked eye.[135] Common pesticides and chemicals such as lead,[136] arsenic, organophosphates, and mercury have been closely associated with cognitive impairment, and more than 200 chemicals have been shown to be neurotoxic in humans.[137] It is not just factory pollutants that can

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133. Some athletes, for example, feel they have no other choice but to sacrifice their bodies and minds to make money or have a future, if they are even aware of the risks in the first place. *See* Jesse Dougherty, *Former Alabama player Les Williams is one of more than 100 suing NCAA over brain injuries*, WASH. POST (July 2, 2018), https://www.washingtonpost.com/news/sports/wp/2018/07/02/feature/former-alabama-player-les-williams-is-one-of-more-than-100-suing-ncaa-over-brain-injuries/?utm_term=.b8960128a6e9 [https://perma.cc/6DFG-BGTV].

134. Alana Semuels outlines where many of the fault lines occur, particularly in football and other high-contact sports, for those who have the opportunities to avoid the grave repercussions playing football might bring, and those who do not: "the divide on the football field makes it hard not to see how inequality in America is worsening health disparities and raising the specter of another, darker era of American history." Alana Semuels, *The White Flight from Football*, ATLANTIC (Feb. 1, 2019), https://www.theatlantic.com/health/archive/2019/02/football-white-flight-racial-divide/581623/ [https://perma.cc/M2BG-FMNU].

135. Arielle R. Baskin-Sommers & Karelle Fonteneau, *Correctional Change Through Neuroscience*, 85 FORDHAM L. REV. 423, 431–32 (2016).

136. "Chronic exposure to lead has measurable effects on the nervous system due to lead's propensity to accumulate in bone over time. For instance, in an MRI study of 532 former lead workers, high tibia lead was associated with reduced total brain volume, lower volume of gray matter in the insula and cingulum, and diminished white matter volume in the parietal lobes." Despite the fact that lead levels have been largely reduced in the United States, thanks in great deal to better science detailing its deleterious effect on brain development, the presence of lead in water, soil, and wall paint continues to affect many. Lisa H. Mason et al., *Pb Neurotoxicity: Neuropsychological Effects of Lead Toxicity*, BIOMED RES. INT'L, Jan. 2, 2014, at 2.

137. Gennaro Giordano & Lucio G. Costa, *Developmental Neurotoxicity: Some Old and New Issues*, 12 ISRN TOXICOLOGY 1, 3 (2012). Exposure to subclinical levels of toxins such as manganese, methylmercury, polychlorinated biphenyls, ethanol, lead, arsenic, toluene, fluoride, chlorpyrifos, and tetrachloroethylene has been shown to disrupt brain development and normal neurotransmitter function.

have deleterious effects on the brain—chemicals that are found in children's toys, in food, and even in household furniture and appliances can also affect neural development.[138] "[T]he vast majority of chemicals in commerce remain untested for their impacts on neurodevelopment,"[139] and it is quite possible that there are more neurotoxins whose effects have not yet been identified.

The prevalence of neurotoxins and their often-deleterious effects on the body and mind can elude public, and certainly legal, discourse. In fact, the magnitude of neurotoxicity is not exactly known and its impact on human health can be understated; even in more developed countries, it is estimated that over 30 million individuals suffer from neurobehavioural illness, but only 20% of these individuals seek medical attention related to such illness.[140] Because many neurotoxins cause non-distinct clinical manifestations—such as nausea, headaches, pain, irritability, dizziness, fatigue, and difficulty concentrating—it is often difficult to diagnose with reasonable certainty, as is required in tort law to recover damages, whether someone is suffering from exposure to toxins. Aside from issues related to proving causation, toxic tort litigation can also require extensive preparation and testing, substantial financial resources, and expert testimony to interpret the evidence, which can be prohibitively expensive for many litigants.

As reliance on neuroscience technology and neurobiological research gain is augmented, more litigants will be able to overcome these obstacles and bring suit,[141] which may in turn affect legislation

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See James Hamblin, *The Toxins That Threaten Our Brains*, ATLANTIC (Mar. 18, 2014), https://www.theatlantic.com/health/archive/2014/03/the-toxins-that-threaten-our-brains/284466/ [https://perma.cc/668B-EBVG].

138. Bisphenol A, a ubiquitous chemical found in many plastics, has neurobiological effects. Linda S. Birnbaum et al., *Environmental Health Science For Regulatory Decisionmaking*, 21 DUKE ENVTL. L. & POL'Y F. 259, 279 (2011).

139. *Id.*

140. Adeniyi Anetor et al., *Environmental Chemicals and Human Neurotoxicity: Magnitude, Prognosis and Markers,* 11 AFR. J. BIOMEDICAL RES. 1, 1 (2008).

141. "It is a given that many subclinical events, once considered invisible and thus speculative, will become detectable and hence objectively verifiable." Jamie A. Grodsky, *Genomics and Toxic Torts: Dismantling the Risk-Injury Divide*, 59 STAN. L. REV. 1671, 1704 (2007). Grodsky wrote this about genetic testing, but it remains true for neuroscientific testing as well. *See, e.g.*, Hose v. Chi. Nw. Transp. Co., 70 F.3d 968, 973 (8th Cir. 1995) (finding no abuse of discretion where the district court admitted PET evidence to show injuries consistent with manganese encephalopathy); In re Welding Fume Prods. Liab. Litig., 245 F.R.D. 279, 298 n.111 (N.D. Ohio 2007) (considering MRI and PET scans demonstrating whether

or discourse about the acceptable levels of toxic chemicals that can be discharged into the environment.[142] Chronic levels of exposure to toxins such as pesticides, even at low levels, can have profound impacts on the nervous system, especially for children and infants.[143] Health effects may occur years after minor exposure to toxins in the environment or in residues ingested through food and water.[144] Neuroscience studies illustrate dysfunctions in brain and behavior[145] that may be attributable to ecological toxins, and such studies have found that a number of toxins are risk factors for the development of neurodegenerative diseases such as Alzheimer's or Parkinson's later in life.[146] Chronic exposure to neurotoxic substances can also be associated with violence, depression, and substance abuse.[147]

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exposure to welding fumes and manganese can cause, contribute to, or accelerate a Parkinsonian syndrome).

142. For example, researchers have used fMRIs to detect the effect of prenatal methylmercury exposure in adolescents and have used MRIs to examine how the chemicals appear to cause thinning of the cortex in children's brain structure. Hamblin, *supra* note 137.

143. *See* Laura Y. Cabrera, *Pesticides: A Case Domain for Environmental Neuroethics*, 26 CAMBRIDGE Q. HEALTHCARE ETHICS 602, 603 (2017) ("[P]esticides readily cross the placenta and bioconcentrate in breast milk, resulting in early-life exposure during critical prenatal neurodevelopment. . . . Research indicates that children born to mothers exposed to pesticides during pregnancy . . . [can] lag . . . two years behind in motor and spatial development when compared with children of mothers without [this] exposure. Other studies have found an association between residential proximity to agricultural fields where exposure to pesticides during pregnancy was correlated with autism spectrum disorder.") (footnotes omitted).

144. In the case of organophosphates, for example, individuals might develop impaired cognitive and psychomotor function a few weeks after exposure, and, in some cases, effects were observed ten or more years after poisoning, suggesting that the residual damage is permanent. *Id.* at 605.

145. For example, neuroscientists use brain scans to assess the patient's sensory, motor, reflex and cranial nerve function to diagnose and monitor substances like lead and mercury on the peripheral nervous system. Anetor et al., *supra* note 140, at 10.

146. Baskin-Sommers & Fonteneau, *supra* note 135, at 431 ("Research attributes exposure to synthetic chemicals, including those found in drugs and pesticides, to damage of dopaminergic neurons in the nigrostriatal system . . . depletion of dopamine in the SN pars compacta and subsequent cell death . . . . Additionally, beta-amyloid protein plaques and intracellular neurofibrillary tangles are linked to toxic environmental exposure, as is inflammation of the brain and accumulation of trace metal elements in brain regions, such as the basal ganglia.").

147. Herbert L. Needleman et al., *Bone Lead Levels and Delinquent Behavior,* 275 JAMA 363, 367 (1996).

Similar to victims of emotional trauma, PTSD, and mTBIs, neurotoxin victims often face difficulties—whether under common law, contract, or policy—when their injuries are not physically visible and thus have been historically difficult to demonstrate.[148] In cases of asbestosis, for example, insurance coverage is often triggered only when the disease causes "bodily injury" even though the policy does not delineate exactly what counts as such injury and when it occurs.[149] Some courts have ruled that the microscopic tissue damage caused by asbestos exposure constitutes bodily injury, whereas others have ruled the opposite, finding that a bodily injury must be "an injury, sickness, or disease," when one's sense of well-being is adversely affected or impaired, and thus have preferred a principle of severity.[150] The problem with this is that many neurological injuries are insidious, and not severe or compensable until it is too late—that is, their debilitating effects have already begun and may not be curable by the time a litigant can prove their existence in court.[151]

The existence of these toxins in the environment represents an important challenge to environmental justice and human rights. There are gross inequities between resource-poor and industrialized countries[152] as well as between different socioeconomic and racial

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148. Daniel A. Farber, *Toxic Causation*, 71 MINN. L. REV. 1219, 1247 (1987) ("The only real difference between the automobile case and the toxics case is that better information is available about the events in the automobile case whereas the relevant biological events in the toxics case are unobservable.").

149. Shen, *supra* note 85, at 2118. Asbestos is a prime example of a latent injury claim.

150. Am. Home Prods. Corp. v. Liberty Mut. Ins. Co., 565 F. Supp. 1485, 1489 (S.D.N.Y. 1983).

151. This latency is exacerbated by the sluggish, and often ineffective, review process that the Environmental Protection Agency (EPA) and other agencies go through to determine whether to ban a substance or not, such as in the case of the highly toxic insecticide, chlorpyrifos. Megan K. Horton et al., *Neuroimaging is a novel tool to understand the impact of environmental chemicals on neurodevelopment*, 26.2 CURRENT OPINION IN PEDIATRICS 230, 233–34 (2014).

152. Resource-poor countries often have rudimentary pesticide registration, regulation, handling, and enforcement requirements. Unsurprisingly, they can experience pesticide overload per capita, including from pesticide products that are banned elsewhere. Furthermore, pesticide labels often are not listed in the local language nor are written in a manner easily understandable by average consumers. Cultural and contextual considerations are often overlooked as well when distributing pesticides to these locations. For example, climatic conditions or limited budgets might make it impractical to wear suggested protective clothing. Discrepancies such as these contribute to further disparities in pesticide burden. Cabrera, *supra* note 143, at 606.

groups[153] within countries.[154] Those with lower socioeconomic status are more likely to live in areas where toxins are present, to have occupations that involve direct contact with toxins, and to have overall less bargaining power and access to education to treat or prevent them. The incidence of lead poisoning, for example, is associated with "socioeconomic status, rurality, race, age, and the date one's residence was built." [155] Poorer urban children are at the highest risk for neurotoxicity, "presumably due to the presence of lead in older building materials and reduced access to sources of nutrition."[156] Exposure to these toxins can further magnify inequalities and hamper educational opportunities, especially considering the young age of many lead poisoning victims.[157]

Although there is substantial evidence demonstrating the impact of certain pesticides on brain and mental health, the synergistic and cumulative effects of many toxins can be difficult to measure and might persist for years before detection. We need better and more preventative methods to determine which chemicals have neurotoxic effects, and neuroscience research and scanning technologies can

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153. For example, it is well documented that there are disproportionate levels of lead paint and landfills (from which toxic substances such as mercury can seep) located in communities of color or lower-income populations. People in these communities may already be at a disadvantage in obtaining costly medical evidence and are prone to suffering long-term neurological illnesses. Disparities such as these are but one window into the type of neurological injuries that some communities disproportionately face, and could be remedied by tort law that is more proactive in recognizing invisible injuries. *See generally* Benfer, *supra* note 59 (documenting above); Robert D. Bullard, *Race and Environmental Justice in the United States*, 18 YALE J. INT'L L. 319, 334 (1993) (explaining that low-income and minority communities suffer most from the nation's environmental problems and have not had success in preventing construction of waste and other polluting facilities).

154. Prisoners, and those who live and work near prisons, for example, are particularly vulnerable to toxin exposure. *See* Prison Ecology Project, NATION INSIDE, https://nationinside.org/campaign/prison-ecology/ [https://perma.cc/C3N7-FKKH].

155. Mason et al., *supra* note 136, at 3.

156. In the 1970s, the average U.S. preschool child had 15 micrograms of lead per deciliter of blood, eighty-eight percent of children had a level exceeding 10 μg/dL—twice what the CDC currently considers toxic—and the average level was markedly higher at 23 μg/dL for poor black children. Hamblin, *supra* note 137, at 11.

157. For instance, scientists have determined that pesticides might be implicated in the rise in children's neurodevelopmental disorders. Cabrera, *supra* note 143, at 606.

advance that goal.[158] Various domestic laws[159] and international agreements[160] demand a right to a healthy environment, including one free of neurotoxins, but the results are imperfect.[161] As the technology becomes more accessible and less expensive, litigants using neuroscience can be the catalysts to show just how detrimental exposure to these toxins can be. Neuroscience evidence could bolster a possible public nuisance action for use of pesticides, metals, and other chemicals: whereas in the past the consequences of toxins in the environment might be felt too late and a litigant could only recover if he or she had an increased risk of future harm, neuroscience can show effects in the brain in real time. We must also ensure that these technologies are as accessible as possible to all; that detecting, predicting, and screening for neurotoxicity is not prohibitively costly for those with lower incomes; and that the public receives better education on potentially harmful substances.

III. CHALLENGES TO AND WEAKNESSES OF NEUROSCIENCE'S USE IN THE LAW

While neuroscience technology may lead to a fairer legal system, it is still evolving, and despite how tempting it is to draw conclusions from its seductive, technical medical data and graphs, it

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158. In the European Union, for example, if a chemical is deemed potentially neurotoxic from testing, it will be strictly regulated. Those regulations "can [later] be relaxed if subsequent testing shows less harm than initially anticipated." Cabrera, *supra* note 143, at 609.

159. The Toxic Substances Control Act is the primary U.S. law regulating chemicals used in everyday products. It requires testing for only a small percentage of chemicals deemed as "unreasonable risks" and has grandfathered over 62,000 chemicals already on the market in the 1970s. Toxic Substances Control Act of 1976, 15 U.S.C. § 2601 (2016). Neuroimaging for these chemicals can be an impetus for stronger chemical safety regulation or policy. Sarah A. Vogel & Jody A. Roberts, *Why the Toxic Substances Control Act Needs an Overhaul, and How to Strengthen Oversight of Chemicals in the Interim*, 30 HEALTH AFF. 898 (2011), https://www.healthaffairs.org/doi/pdf/10.1377/hlthaff.2011.0211 [https://perma.cc/EXH9-UDXH].

160. *See, e.g.*, United Nations Conference on the Human Environment, G.A. Res. 27/2994, U.N. Doc. A/RES/27/2994 (Dec. 15, 1972) (issuing a statement "[r]eaffirming the responsibility of the international community to take action to preserve and enhance the environment and, in particular, the need for continuous international co-operation to this end").

161. For example, chlorpyrifos, which can affect fetal brain development, is classified as "very highly toxic" to birds and fish, and "moderately toxic" to mammals, but is still used widely in agriculture, greenhouses, wood products, and golf courses. Hamblin, *supra* note 137, at 4.

cannot yet be relied on as a mind reader, predictor of future actions, or litmus test.[162] While understanding the circuitry and cognition processes of the brain may lead to increased knowledge of human behavior, neuroscience, like any other scientific field, does not always isolate a specific cause that leads to a specific effect. Indeed, the potential value of neuroscience to improve decision-making accuracy and to advance justice must be reconciled with the potential for exaggeration, hype, and premature application of scientific theses that are not yet repeatedly validated. Moreover, incorporating neuroscience into the law is not without its ethical and policy concerns, raising apprehensions regarding conceptions of free will, mental privacy, and personal liberty.[163] Additionally, traditional dichotomies in tort recovery might become superfluous if litigants can demonstrate suffering from emotional injuries using brain scans.[164]

The use of neuroscience technology in the courtroom and in legal policy presents two main categories of concerns: one regarding the reliability and readiness of this technology for use as evidence, and another encompassing the normative, ethical, and policy concerns we might have about the use of this technology. Sections A and B of this Part examine each of these in turn. Section C explains why, despite these concerns, neuroscience is ultimately a useful tool for policymakers and potential litigants. This Section also proposes a number of strategies for legislatures, courts, and society to take to regulate the use of neuroscience data in civil courtrooms.

A. Evidentiary Concerns

From an evidentiary standpoint, it is vital to consider criticisms and weaknesses of utilizing neuroscientific data in the courtroom. Primarily, neuroscience must wrestle with meeting a

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162. Aspinwall et al., *supra* note 40, at 846.

163. *See, e.g.*, Giulio Mecacci & Pim Haselager, *Identifying Criteria for the Evaluation of the Implications of Brain Reading for Mental Privacy*, SCI. & ENGINEERING ETHICS 1 (Dec. 15, 2017), https://link.springer.com/content/pdf/10.1007%2Fs11948-017-0003-3.pdf [https://perma.cc/2A7H-PG42] (analyzing how contemporary brain scanning technologies may impact private character of mind).

164. *See* Erica Goldberg, *Emotional Duties*, 47 CONN. L. REV. 809, 824–25 (2015) (arguing that tort law embeds normative ideals about which harms are protectable in society, and therefore, the line between protectable and unprotectable harm should not be determined by the latest trends in neuroscience).

threshold of reliability before courts can accept its use in factfinding.[165] Some of those problems include a lack of a baseline, extrapolating information gleaned in generalized studies to a specific instance, confounding social and environmental factors that might influence the data, and the unknown rate of false positive and false negatives. This Section will address each of these limitations.

A significant problem in using neuroimaging evidence is establishing a plaintiff's baseline brain function.[166] For example, without some evidence of an individual's condition prior to an incident, it is hard to evaluate whether a particular incident actually caused the individual psychological harm or aggravated it further, or whether the individual was suffering from a pre-existing condition. It is unlikely that a plaintiff will have had previous brain scans to compare to the current scan.[167] Similarly, brain scans taking place long after a particular incident occurred may be of limited diagnostic or forensic use.[168] Although the plaintiff may still be experiencing injury or harm, a number of other causes between the injury and the scan could have contributed to the neuroimaging results.

Establishing a baseline goes to the issue of causation; that is, whether a plaintiff's harm is really due to the event in question.[169]

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165. Scientific consensus on how to interpret the relationship between the observable BOLD response in fMRIs and conclusions regarding mental states of subjects is "still evolving." Eggen & Laury, *supra* note 41, at 302.

166. In some cases, as reliance on neuroscience increases and gains popularity, the lack of an individual baseline scan to compare to a post-injury scan may cease to be as problematic. In fact, the NFL and NCAA now give baseline neurological exams to prospective players before they ever play in a game. Carl Zimmer, *The Brain: What Happens to a Linebacker's Neurons?,* DISCOVER MAG. (Aug. 18, 2010), http://discovermagazine.com/2010/jul-aug/18-brain-what-happens-to-a-linebackers-neurons [https://perma.cc/6XS2-HD57].

167. Perhaps institutionalizing periodic brain scans for professional and amateur athletes would be one way to implement such an idea. Alternatively, other measures can help paint a "before" picture, such as circumstantial evidence including school, employment, and medical records.

168. Jonathan Brodie, a New York University psychiatrist, testified against an expert using fMRI scans to exculpate a defendant, saying, "the scans are of wonderful technical quality, but so what? They're not relevant here . . . . Using an fMRI scan done in September of 2009 . . . to indicate a thought process that was going on in 1983 could hardly be more silly." Greg Miller, *fMRI Evidence Used in Murder Sentencing*, SCIENCE MAG. (Nov. 23, 2009), http://www.sciencemag.org/news/2009/11/fmri-evidence-used-murder-sentencing [https://perma.cc/Z6QU-9P24].

169. In tort law, in order to successfully recover monetary damages, a plaintiff must not only demonstrate an injury, but also that the defendant's action

Although neuroscience has made great strides, we still possess limited understanding of the physical link between brain activity and behavior and must continue to emphasize the distinction between correlation and causation when using neuroimaging data in court. Though fMRIs can accurately measure changes in oxygenated blood flow, interpreting those changes as reliable indicators of particular types of thought, or as reliable indicators of what a region of the brain is actually doing, requires a series of inferential steps that involve statistical analysis, interpretation, and comparison to other information. In fact, studies from psychology, psychiatry, and public health have shown that a traumatic event may be a cause of a mental disorder but may not be the proximate or sole cause.[170]

As insightful as brain scanning techniques are, it is crucial to remember that they are proxy measures of brain activity. There is substantial "human judgment" between data acquisition and the creation of the "eye-catching fMRI images that we have become accustomed to seeing."[171] Experts' analyses can help interpret neuroscience data, but they can also lead to distortions of it. In the courtroom, judges must consider the credibility of the neuroscience evidence, the ways in which it might be interpreted or manipulated, and its potential impact on jurors.

Another criticism of reliance on this technology is that there is a significant difference between how a brain functions in laboratory experiments and how a brain experiences the real world in the midst of an incident.[172] It may be difficult, if not impossible, to approximate the real-world context during a brain scan. Additionally, most of what we know about brain function comes from studies that average results from groups of individuals; as a result, it is challenging to predict the exact nature of brain dysfunction in individual subjects. Brains and their responses vary not just across individuals but also within particular individuals over time due to external contextual factors like

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caused the injury. Cornell L. Sch., *Tort,* LEGAL INFO. INST., https://www.law.cornell.edu/wex/tort [https://perma.cc/XJR9-TUL6].

170. Oliver R. Goodenough & Micaela Tucker, *Law and Cognitive Neuroscience*, 6 ANN. REV. L. & SOC. SCI. 61, 66 (2010) (arguing that the brain is a composite of influences incorporating numerous social, cultural, and personal experiences; even medication can alter fMRI signals).

171. Owen D. Jones & Christopher S. Sudby, *Neuroscience in the Law*, 11 SCITECH LAW. 4, 4 (2015).

172. Many neuroscience studies are done on compliant test subjects, often college students. Cost, the availability of volunteers, and ethical and practical hurdles make it difficult to generate more realistic or diverse studies. Jay Aronson, *The Law's Use of Brain Evidence,* 6 ANN. REV. L. SOC. SCI. 93, 100 (2010).

mood, medication, or sleep deprivation.[173] It is imperative to consider false positives and false negatives: a person could subjectively experience pain because of a low pain threshold even though it may not manifest on a scan, or she could feel no pain while a scan indicates that she should be feeling it.

Keeping these limitations in mind, we must weigh the probative value of neuroscience evidence against potential prejudicial impact on judges and juries.[174] In other words, fact finders may tend to trust brain scans simply because they are impressed by the images and believe them to be scientifically objective.[175] According to Federal Rule of Evidence 403, the court may "exclude relevant evidence if its probative value is substantially outweighed by a danger of one or more of the following: unfair prejudice, confusing the issues, misleading the jury, undue delay, wasting time, or needlessly presenting cumulative evidence."[176] Colorful neuroimaging in a courtroom may seem more reliable to a jury than is justified. On the other hand, this is nothing new: all scientific evidence, particularly when it comes from more novel technologies, can lead to confusion and is rarely, if ever, 100% dispositive.[177]

Neuroscience technologies are still developing and require further corroboration before they are ready for widespread use in the

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173. Greely, *supra* note 18, at 182 ("Brains are complicated and individual . . . . It is unlikely that everyone's brain will react the same way to exactly the same stimulus.").

174. 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, 1203 (2010) (arguing that presentation of brain images might be misinterpreted by or confuse jurors).

175. While it is difficult to estimate how influential neuroscience evidence can be in the courtroom, Nita Farahany found that in cases where defendants used neuroscientific evidence, they received a slightly more favorable outcome. Greg Miller, *The Brain Gets Its Day in Court*, ATLANTIC (Mar. 1, 2016), https://www.theatlantic.com/science/archive/2016/03/neurolaw-brain-scans-court/471615/ [https://perma.cc/3GYZ-LZSK].

176. FED. R. EVID. 403. Rule 403 has been invoked to exclude evidence from polygraph tests. Greg Miller, *Brain Scans of Pain Raise Questions for the Law*, 323 SCI. 195 (2009).

177. Hank Greely points to the forensic use of DNA, unreliable eyewitnesses, and even the introduction of PowerPoint slides as examples of controversial or imperfect pieces of evidence in the past. Seminowicz et al., *supra* note 95, at 230–31. Moreover, there is evidence that neuroscience evidence may not be as excessively persuasive as some believe it to be. Nicholas J. Schweitzer et al., *Neuroimages As Evidence in a Mens Rea Defense: No Impact*, 17 PSYCHOL. PUB. POL'Y & L. 357, 366 (2011) (finding no evidence that neuroimaging unduly influences juries over verbal neuroscience-based evidence).

courtroom. Ensuring scientific reliability, commissioning larger and more diverse sample pools, developing theories to help explain and test correlations, and increasing scientific literacy among decisionmakers will contribute to increasing neuroscience's legal value and to decreasing skepticism. Still, it is important to note how advanced brain scan technology has become—for example, scientists are now able to evaluate specific structures, chemical levels, and individual receptors in the brain.[178] Perhaps the best way to approach the power of these technologies is to use neuroscience as only one factor among others—as a piece of evidence added to the whole puzzle that the triers of fact consider in reaching a decision. Neuroscientific data alone may not always be conclusive but could be corroborated with litigants' self-reports and behavior.[179]

While the limitations outlined in this Section may support evidentiary challenges or grueling cross-examination, they do not justify an absolute legal barrier to the use of brain scan technology in the legal arena, especially considering the probative value that the data can provide. Although neuroscientific imaging methods may never be infallible or definitive enough to supersede other forms of evidence, there are many suffering people to whom these methods can finally give credence and validation.

B. Normative, Ethical, and Policy Challenges to Neuroscience in the Courtroom

Science may inform the law but it does not dictate it. As a society, we may want to maintain distinctions between physiologically similar harms for normative reasons. Courts are skeptical of recognizing invisible injuries for several reasons other than the evidentiary difficulties discussed in Section A. They may fear that eliminating the distinction between awarding economic damages for physical but not invisible injuries is the first step in a slippery slope.[180]

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178. Greely, *supra* note 18, at 181.

179. One could envision, for example, an expert using generalized neuroscience statistics as a guide against an individual's data and say something like, "when we see this pattern of brain activation, in similar circumstances, 90 percent of people we believe to be honest report that they're in pain" rather than conclusively decide that the data says something certain about the individual. *See* Greely, *supra* note 18, at 182–83.

180. *See, e.g.*, Metro-North Commuter Railroad Co. v. Buckley, 521 U.S. 424, 442 (1997) (expressing concerns about recognizing "unlimited and unpredictable" liability and rejecting the plaintiff's claims to damages and monitoring services on

A number of scholars defend the relevance of the distinction between physical and emotional harm, especially in tort law, by asserting that a duty to maintain one's own emotional well-being can benefit both tort plaintiffs and defendants because it incorporates normative ideals about identity, consent, autonomy, social justice, and social welfare.[181] After all, not everything that we "dislike or resent, and wish to avoid, is harmful to us,"[182] including unpleasant but not unequivocally debilitating mental states such as disappointment, hurt feelings, broken hearts, and shame. Not all stress is bad and negative experiences or emotions can be helpful and constructive; these types of injuries are inherent in the experience of being human and may not be worthy of compensation in the courtroom.

Additionally, the use of neuroscience technology in the courtroom or its incorporation into legislation could backfire and hurt some litigants.[183] It is imperative to consider whether we, as a society, want to develop new standards of objectively measuring injury or harm. While using brain imaging technology might allow compensation for some litigants who would otherwise be unable to demonstrate an objective measure of their pain and suffering, a reliance on these technologies might exclude other litigants who are unable to show this harm on a device.[184] As neuroscience evidence becomes a norm in the courtroom, litigants unable to proffer this evidence—whether due to cost or other involuntary means—may be disadvantaged or their lawyers charged with ineffective assistance of counsel.[185]

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the grounds that he could only recover them if and when he manifested symptoms of a disease).

181. Erica Goldberg, *Emotional Duties*, 47 CONN. L. REV. 809, 811 (2015) (maintaining that the distinction between physical and emotional harm "should be based on a duty that we all have to reasonably regulate our own emotional well-being").

182. JOEL FEINBERG, 1 THE MORAL LIMITS OF THE CRIMINAL LAW: HARM TO OTHERS 45 (1984).

183. For example, increased reliance and insistence on brain scanning techniques in litigation might even prolong PTSD. L. H. Field, *Post-traumatic stress disorder: A reappraisal*, 92 J. ROYAL SOC'Y MED. 35, 35 (1999) ("[O]ngoing litigation acts as an artificial reinforcing factor for unpleasant memories and their accompanying affect.").

184. For example, some litigants might be unable to show harm due to false positives or false negatives. *See supra* Part III.A.

185. Deborah W. Denno, *The Myth of the Double-Edged Sword: An Empirical Study of Neuroscience Evidence in Criminal Cases*, 56 B.C. L. REV. 493, 494 (2015).

If some type of neuroimaging evidence is admissible and becomes expected, can a litigant be penalized for not proffering such evidence? In one case, the United States Court of Appeals for the Eighth Circuit suggested that a plaintiff's expert should have ordered a PET or SPECT scan of the plaintiff's brain to support a PTSD claim.[186] Because the expert failed to do so, the court rejected the argument that the plaintiff suffered physical injury to her brain. It is not farfetched to imagine a future where defense counsel routinely requests fMRI tests or requires that a plaintiff be made available for an fMRI, as is currently done in DNA or other forensic tests, to substantiate claims of pain and suffering.

Increased use of neuroscience data in the courtroom could also backfire by creating a problematic perception that a claimant has a duty to mitigate his or her own harm. Might victims of tortious wrongdoing be required to avert the aggravation of their own injuries? Expecting invisible injury victims to, say, go to a therapist or take medications or painkillers, and penalizing them with a lower damage award if they do not, could infringe upon cognitive liberty and other societal or cultural notions of autonomy.

Socioeconomic obstacles to using this technology to boost litigants' claims are also concerning. The cost of neuroimaging scans may be prohibitive for some tort litigants.[187] A preference for scans might prejudice decisionmakers against claimants who cannot afford the technique or whose condition cannot reliably be discerned by a scan.

Neuroscience and its potential to eliminate the physical-mental divide in our legal system can also raise a number of constitutional issues, possibly implicating the First, Fourth, Fifth, Seventh, Eighth, or Fourteenth Amendments. First Amendment doctrine relies on the notion that speech that causes emotional harm should be less susceptible to regulation than conduct that causes physical harm, a norm that neuroscientific insights might challenge. A brain scan could also constitute a search of the person, implicating the Fourth Amendment.[188] The Fifth Amendment protects individuals

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186. Lloyd v. American Airlines, 291 F.3d 503, 511 (8th Cir. 2002).

187. Costs for fMRI, PET, and other scans vary by region and by insurance plans. According to one source, an fMRI scan costs $539 per hour. Yale Sch. of Med., *Usage Charges*, MAGNETIC RESONANCE RES. CTR. (July 1, 2018), http://mrrc.yale.edu/users/charges.aspx [https://perma.cc/WYK4-EAG7].

188. Rosen, *supra* note 36 (asking whether police can "get a search warrant for someone's brain").

from being forced to incriminate themselves—can a brain scan disrupt that notion? To the extent we have a right to mental privacy and cognitive liberty, who should be entitled to access this information, and is this right protected in the Constitution? The ways use of neuroscience in the courtroom could implicate the right of trial by jury, protected by the Seventh Amendment, and due process and equal protection rights, protected by the Fourteenth Amendment, are numerous and complex, and likely will become relevant as its use in the courtroom becomes more prevalent. Finally, punishing people for their neurobiological thoughts rather than for their actions could violate the Eighth Amendment's ban on cruel and unusual punishment.[189] These questions are beyond the scope of this Note, but remain important to consider.

C. The Way Forward: Creating Law and Policy Informed by Neuroscience Research

Although neuroscience research and tools will never provide all of the answers about a given case or person, its probative value outweighs the risks mentioned in Sections A and B. Insights from functional neuroimaging evidence are increasingly illuminating, relevant, and reliable, and they can at least supplement more conventional evidence. Neuroscientific data can increase confidence in the law's conclusions and in some cases challenge our confidence in those conclusions, and it can inform how we define tortious behavior. Neuroscience and law will inexorably continue to intersect as our understanding of the brain becomes more sophisticated and as lawyers become more familiar with neuroscientific evidence's potential. Therefore, it is important to discuss regulatory, judicial, and doctrinal options for neuroscience in the legal field.

Because careful consideration is required to determine when the use of neuroscience evidence is appropriate, it might be helpful to establish a working group or commission to develop rules of evidence to accommodate the technological developments. There is already an organization focused on using neuroscientific insights to inform legal policy in the criminal law context,[190] but perhaps one focused on civil

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189. The idea of holding people accountable for their predispositions rather than their actions "poses a challenge to one of the central principles of Anglo-American jurisprudence: namely, that people are responsible for their behavior, not their proclivities—for what they do, not what they think." *Id.*

190. *See* MACARTHUR FOUND. RESEARCH NETWORK ON LAW & NEUROSCIENCE, http://www.lawneuro.org/ [https://perma.cc/RJT3-GEXU].

and tort contexts should be established as well. This group could include neuroscientists, psychologists, economists, and lawyers, among others, and should be socioeconomically inclusive so that all parts of society are allowed equal input. This group could discuss the various ways that neuroscience might be used and especially how it might be misused in the courtroom. Researchers and scientists could present their findings and explain the limitations of their findings (such as making it clear that a study consisted of, say, mostly college-age students and that an averaged data point might not extrapolate to a particular individual); behavioral psychologists and economists could interpret these findings and offer predictions about how they might play out in society; and lawyers could offer their perspective on how a judge or jury might consider and respond to that data. Policymakers could then propose model laws to accommodate these pieces of evidence or perhaps offer guidelines for courts interpreting neuroscience evidence in *Daubert* proceedings. It might be beneficial to craft a standard for the use of neuroscience evidence in court and for policy determinations similar to the standards used for genetic data or forensic testing and to consult methods employed by groups such as the National Conference of Commissioners on Uniform State Laws,[191] including research, drafting, and oversight committees.[192]

In judicial proceedings, consulting neuroscience and cognitive psychology experts will be crucial. Under federal evidentiary standards, neuroscience data should be viewed with caution, but should still be considered as one of the factors in an overall evaluation of harm. The evidentiary concerns listed in Section A can be mitigated by instituting clear jury instructions on how to analyze neuroscience evidence objectively and meticulously. As long as juries and judges are instructed to consider neuroscience data with a critical eye, neuroscience evidence should be accepted in court as substantiation of invisible injuries and it should be viewed as helpful, though not dispositive. A variety of indicators could be used to evaluate the neuroscience evidence—such as how reliable the data is or who exactly

191. One possible avenue would be for the National Conference of State Legislatures (NCSL) to publish a uniform state law regarding how to interpret neuroscience research in a courtroom.

192. *See, e.g.*, CTR. FOR LAW & THE PUB.'S HEALTH AT GEORGETOWN & JOHNS HOPKINS UNIVS., THE MODEL STATE EMERGENCY HEALTH POWERS ACT (2001), https://www.aapsonline.org/legis/msehpa2.pdf [https://perma.cc/RJN4-AKQ9] (a proposed act written to help the NCSL formulate law accordingly). A similar method could be used in the neuroscience field.

the data comes from—and could thereby inform a court or a jury on how much weight they should give the evidence.

Courts and legislatures will increasingly be called upon to articulate new boundaries of liability in the area of invisible harms, but so will society at large. At the very least, neuroscience will force a reconsideration of what some see as outmoded distinctions in the law. As Betsy Grey asserts, "if there is to be no or lesser recovery for mental distress claims, then this choice should be better explained by policy concerns about ruinous liability and a desire to reserve funds for victims of other harms rather than based on an unexamined physical-mental boundary."[193] Furthermore, taking into account how research has chronicled the damaging neurobiological effects of harms such as PTSD, mTBIs, and neurotoxins, neuroscience might change what we see as reasonably foreseeable for the purposes of determining proximate causation in tort law. If neuroscientists can show a strong correlation between these harms and neurological and psychological injuries, plaintiffs may find the causation prong of a tort claim easier to prove.

Ultimately, we may not want to remedy every harm that one can experience in society. But more objective, measureable information that is rooted in the physiology of invisible injuries could reveal that some actions injure more than others. We might want to protect against these actions by redrawing the lines in our tort system. Neuroscience might be able to tell us what traditionally unprotected tortious harms can cause long-term damage or have other harmful effects. For example, a physical disability or injury is generally seen as more debilitating than a bully's harsh words, but what if a reliable brain scan showed that those words affected a particular individual so greatly that he could not attend school, sleep, or socialize?[194] While we might not want to bring hurt feelings or broken hearts into litigation, neuroscience shows that words, in some instances, can hurt in a quantifiable way.[195] Once neuroscience technology is able to verify injuries like this—and the technology is close if not there already—tort law should depend less on the arbitrary physical-mental divide and

193. Grey, *supra* note 113, at 27.

194. "If the plaintiff is to recover every time that her feelings are hurt, we should all be in court twice a week. . . . But this is a poor reason for denying recovery for any genuine, serious mental injury. It is the business of the law to remedy wrongs that deserve it, even at the expense of a 'flood of litigation.'"). William L. Prosser, *Intentional Infliction of Mental Suffering: A New Tort*, 37 MICH. L. REV. 874, 877 (1939).

195. Eisenberger, *supra* note 81, at 42.

focus more on an individual's particular experience of harm, its severity for the particular litigant, and the extent to which the harm can be attributed to the offender's conduct.

It may be difficult to assess damages for some of these torts, and financial compensation alone cannot necessarily restore an invisibly injured plaintiff. However, financial compensation can still serve the important purpose of reifying social norms against the harm and affirming a plaintiff's bodily integrity.[196] Indeed, the insights from this technology can help, protect, and dignify[197] people who experience injury and impairment, especially for those who previously have never been given such a platform.

CONCLUSION

Just as neuroscience technology can be used to rehabilitate or sentence defendants more fairly in criminal law,[198] it can also yield a more just allocation of resources in civil and human rights law.[199] Not only will it provide more objective evidence for invisible injuries, but it can also provide due process to those who traditionally have not had access to courts, particularly for those in more vulnerable populations. Despite some critical limitations, the aggregate of insights produced by neuroimaging is impressive and is only improving in reliability. More studies, with more diverse populations and greater attention to possible countermeasures, as well as some testable predictive theories about expected activation patterns, would greatly increase confidence

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196. Nita A. Farahany, The Costs Of Changing Our Minds 12 (June 8, 2014) (unpublished manuscript) (on file with the Columbia Human Rights Law Review) (noting that tort compensation for the emotional suffering resulting from rape, for example, "recognizes the enduring impact on victims, and expresses social condemnation of the act and its consequences").

197. Tommy Jarrett, who suffered from PTSD and lost wages after witnessing a young girl die in a car accident, is one such litigant whose day in court helped restore his life and dignity. *Invisibilia: Emotions*, NAT'L PUB. RADIO (June 1, 2017), https://www.npr.org/templates/transcript/transcript.php?storyId=530928414 [https://perma.cc/ZA4N-E9K4] ("[E]motional distress is the same thing as physical damage. It can wreak havoc on somebody's life, and it can destroy them.").

198. *See generally* Gertner, *supra* note 10 (examining how neuroscience can help develop a more informed sentencing approach and reduce the rate of incarceration).

199. If neuroscience "does eventually provide significant insights into the mind, it may well be necessary to revamp our thinking on the Anglo-American system of criminal justice and perhaps our approach to the law entirely." Elizabeth Bennett, *Neuroscience and Criminal Law: Have We Been Getting It Wrong for Centuries and Where Do We Go from Here?*, 85 FORDHAM L. REV. 437, 451 (2016).

in neuroscience data. Additionally, suggestions like the ones made above—for a working group to propose model laws or ways to interpret neuroscience evidence in the courtroom—are concrete ways to incorporate insights from neuroscience into the law in a sensible and scrupulous manner.

Neuroscience can offer a better understanding of human behavior and the potential for improved policymaking, increased accuracy, and decreased oversights in advancing justice. Its insights challenge our traditional tort doctrine and policy, forcing us to clarify our reasons for allowing or barring compensation in various contexts, and by extension, which human rights our society most values. Advances in neuroscience help eliminate preconceived assumptions about invisible injuries and suggest that failure of proof is no longer a sufficient excuse to cling to old, outdated doctrines. If tort law is about rectifying a harm inflicted upon someone in society, and as a society we value not only physical but also emotional and mental well-being, then this distinction undervalues the amount of pain and suffering that some people feel and it should be revisited.[200]

200. To echo Judge Green, "For Daniel to be left without a remedy under all the undisputed facts in this case is antithetical to the general policy of tort liability in Anglo-American jurisprudence: those who are legitimately injured due to the act or omissions of others should have a remedy in our courts." Ware v. ANW Special Educ. Coop., 180 P.3d 610, 622 (Kan. Ct. App. 2008) (Green, J., dissenting).