Law and Neuroscience in the United States

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Abstract Neuroscientific evidence is increasingly reaching United States courtrooms in a number of legal contexts. Just in calendar year 2010, the U.S. legal system saw its first evidentiary hearing in federal court on the admissibility of functional magnetic resonance imaging (fMRI) lie-detection evidence; the first admission of quantitative electroencephalography (qEEG) evidence contributing in part to a reduced sentence in a homicide case; and a U.S. Supreme Court ruling explicitly citing brain development research.

Additional indicators suggest rapid growth. The number of cases in the U.S. involving neuroscientific evidence doubled from 2006 to 2009. And since 2000, the number of English-language law review articles including some mention of neuroscience has increased fourfold. In 2008 and again in 2009, more than 200 published scholarly works mentioned neuroscience. The data clearly suggest that there is growing interest on the part of law professors, and growing demand on the part of law reviews, for scholarship on law and the brain (Shen 2010). In addition, a number of symposia on law and neuroscience have been held in the United States over the past few years, and despite the notable youth of the field, courses in Law and Neuroscience have been taught at a number of U.S. law schools.

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This vivid interest in neurolaw, from both scholars and practitioners, is born of the technological developments that allow noninvasive detection of brain activities. But despite the rapid increase of legal interest in neuroscientific evidence, it remains unclear how the U.S. legal system – at the courtroom, regulatory, and policy levels – will resolve the many challenges that new neuroscience applications raise.

The emerging field of law and neuroscience is being built on a foundation joining: (a) rapidly developing technologies and techniques of neuroscience; (b) quickly expanding legal scholarship on implications of neuroscience; and (c) (more recently) neuroscientific research designed specifically to explore legally relevant topics. With the institutional support of many of the country's top research universities, as well as the support of the John D. and Catherine T. MacArthur Foundation, among other private foundations and public funding agencies, the U.S. is well positioned to continue contributing to international developments in neurolaw.

This chapter provides an overview of notable neurolaw developments in the United States. The chapter proceeds in six parts. Section 1 introduces the development of law and neuroscience in the United States. Section 2 then considers several of the evidentiary contexts in which neuroscience has been, and likely will be, introduced. Sections 3 and 4 discuss the implications of neuroscience for the criminal and civil systems, respectively. Section 5 reviews three special topics: lie detection, memory, and legal decision-making. Section 6 concludes with brief thoughts about the future of law and neuroscience in the United States.

As judges, lawyers, legislators, and the public become more acquainted with neuroscientific evidence, and as neuroscience continues to produce more legally relevant findings, it is likely that we will see continued expansion of law and neuroscience in the United States.

1 Law and Neuroscience in the United States

In recent years, the United States has been home to a number of important developments at the intersection of neuroscience and law. Just in calendar year 2010, the U.S. legal system saw its first evidentiary hearing in federal court on the admissibility of fMRI lie-detection evidence (*United States v. Semrau* 2010), the first admission of quantitative electroencephalography (qEEG) evidence contributing in part to a reduced sentence in a homicide case (*State v. Nelson* 2010); and a U.S. Supreme Court ruling explicitly citing brain development research (*Graham v. Florida* 2010).

These examples make clear that in the United States neuroscientific evidence has already reached the courtroom in at least some important legal contexts. Preliminary assessments by Nita Farahany, for example, indicate a rapid rate of growth, with twice as many reported cases involving neuroscientific evidence in 2009 as in 2006 (Farahany 2011).

Not only is neuroscientific evidence reaching the courts, but it is also – at least in some contexts – directly affecting the administration of justice. For example, in 2010 jurors in a U.S. state court considered whether Grady Nelson, who had earlier been found guilty of murdering his wife and raping a child, should receive the death penalty or life in prison (*State v. Nelson* 2010). When Nelson was spared the death penalty, interviews with jurors after their verdict revealed that, for some, the proffered neuroscientific evidence was a tipping point. As one juror remarked, "the technology really swayed me . . . . After seeing the brain scans, I was convinced this guy had some sort of brain problem" (Ovalle 2010, p. 1). Whether or not this particular use of qEEG evidence was appropriate, and whether or not the Grady Nelson case was rightly decided, similarly situated legal defense teams will likely consider offering similar types of evidence in the future.

Whether, and how, the use of neuroscientific evidence in the legal system will expand is an open and hotly debated question. A large number of commentators have begun to weigh in on how this intersection of different technologies, analytic methods, and legal contexts may ultimately allow for a more effective and fair legal system (for overviews, see Goodenough and Tucker 2010; Jones et al. 2009; Greely and Wagner, Forthcoming; Aronson 2010; Tovino 2007a).

Since 2000, the number of English-language law review articles including some mention of neuroscience has increased fourfold. In 2008 and again in 2009, more than 200 published scholarly works mentioned neuroscience. The data clearly suggest that there is growing interest on the part of law professors, and growing demand on the part of law reviews, for scholarship on law and the brain (Shen 2010).

In addition, a number of symposia on law and neuroscience have been held in the United States over the past few years.[1] This vivid interest in neurolaw, from both scholars and practitioners, is born of the technological developments that allow noninvasive detection of brain activities. But despite the rapid increase in legal interest in neuroscientific evidence, it remains unclear how the legal system – at the

[1] As a sampling: in 2008, the Berkman Center for Internet and Society and the Petrie-Flom Center for Health Law Policy, Biotechnology and Bioethics of Harvard Law School hosted a roundtable panel titled *Should Criminal Law be Reconsidered in Light of Advances in Neuroscience?*. In 2008, the Initiative on Neuroscience and the Law at Baylor College of Medicine hosted a conference on *Neuroscience and Law*. In 2008, UC Riverside Extension Law & Science Program and the Gruter Institute for Law and Behavioral Research hosted a *Seminar on Law and Neuroscience*. In 2008, the University of Akron School of Law hosted a law review symposium on *Neuroscience, Law, and Government*. In 2009, the MacArthur Foundation Law and Neuroscience Project sponsored a symposium titled *Psychopathy and the Law*. In 2009, the Stanford Technology Law Review hosted a symposium on *Neuroscience and the Courts: The Implications of Advances in Neurotechnology*. In 2009, the Vermont Law Review published a special issue, *Emotions In Context: Exploring The Interaction Between Emotions And Legal Institutions* (which drew heavily on neuroscience research). In 2009, the Gruter Institute for Law and Behavioral Research ran a conference titled *Law, Biology and the Brain*. In 2010, the American Enterprise Institute for Public Policy Research hosted an event titled *Understanding Humans through Neuroscience*. In 2010, Mercer University School of Law hosted a conference on *The Brain Sciences in the Courtroom*. In 2011, the Denver University Law Review hosted a *Symposium on Law and Neuroscience*; and the Dana Foundation hosted a *Law and Neuroscience* conference in New York. Also, in 2011 a *Neuroscience and the Law* forum was co-sponsored by the National Academy of Sciences and the U.K. Royal Society.

courtroom, regulatory, and policy levels – will resolve the many challenges that new neuroscience applications raise.

To address some of these challenges, the John D. and Catherine T. MacArthur Foundation created the *Law and Neuroscience Project*, in 2007, and subsequently created the *Research Network on Law and Neuroscience*, in 2011.[2] The *Project* and the *Research Network*, now headquartered at Vanderbilt University Law School, in Nashville, Tennessee, have fostered interdisciplinary research among more than 50 scientists, law professors, and judges across the United States.

Both the Project and the Research Network have spurred original empirical research to explore brain-imaging techniques for, among many other things: detecting memory and deception; resting-state functional connectivity analysis of impulsivity in juveniles; risk and information processing in addicts; the effects of neuroimaging evidence on juror decision-making; the cognitive processes supporting third-party legal decision-making; and improved methods for making accurate, individualized assessments of psychopathy.

Members have published on neuroscience and law in the context of responsibility, sentencing, evidence, neuroprediction, addiction, juvenile justice, psychopathy, legal and moral reasoning, neuroethics, incidental findings, limits to neuroimaging techniques, emotions, memory, lie detection, pain detection, risk assessment, behavioral genetics, health law, and many other related topics. The Project has also provided education and outreach on neuroscience to more than 800 judges, and developed the first *Primer on Law and Neuroscience* (Morse and Roskies Forthcoming), as well as the first *Law and Neuroscience* case book for law students (Jones et al. Forthcoming). The research, publications, and outreach of the Project – alongside the work of many other notable scholars in the U.S. and elsewhere – are establishing a firm foundation for the future of this interdisciplinary field.

Despite the notable youth of the field, courses in *Law and Neuroscience* have been taught at a number of U.S. law schools, including Vanderbilt University, the University of Colorado, Georgetown University, Mercer University, the University of San Diego, Temple University, Tulane University, and Yale University – reflecting broad and quickly developing interest across the academy. The University of Pennsylvania Intensive Summer Institute in Neuroscience, which will be offered for the fourth consecutive year in 2012, has similarly introduced a number of lawyers to neuroscience.

These collective efforts, in both the legal and scientific communities, have attracted national attention. The press – print, television, and web – has recognized that "law and the brain" stories are of increasing interest to their readers and viewers. For instance, in the past few years:

[2] More information on the Law and Neuroscience Project, and on the Research Network on Law and Neuroscience, is available online at: http://www.lawneuro.org. In addition, two other useful online resources for law and neuroscience information are: (1) the "Neuroethics and Law" blog, maintained by Adam Kolber, at http://kolber.typepad.com; and (2) the Research Network blog at: http://lawneuro.typepad.com.

- *Science* magazine described "neuroscience in court" as one of the seven "Areas to Watch" (2008).
- The *New York Times Magazine* investigated the intersection of law and neuroscience in a cover story, "The Brain on the Stand" (Rosen 2007).
- The NBC Nightly News' *Mind Matters* series explored the neuroscience of psychopaths and mind reading in "Dangerous Minds" (2008).
- The *Wall Street Journal* considered neuroscience evidence in an article "The Brain, your Honor, Will Take the Witness Stand" (2009).
- *Scientific American* ran a piece on "The Legal Brain: How Does the Brain Make Judgments about Crimes" (2009).
- The National Public Radio produced show, *Justice Talking*, ran a week-long series on "Neurolaw: The New Frontier" (2008).

Beyond the headlines of these media stories, of course, are many complex challenges that must be addressed as the U.S. legal system attempts to effectively integrate neuroscience research. It is beyond the scope of this chapter to go in depth on each of these challenges. However, we aim here to introduce readers to many of the most important U.S. neurolaw developments and debates.

The chapter proceeds as follows. Section 1 introduces the development of law and neuroscience in the United States. Section 2 then considers some of the evidentiary contexts in which neuroscience has been, and will continue to be, introduced. Sections 3 and 4 discuss the implications of neuroscience for the criminal and civil systems, respectively. Section 5 reviews three special topics: lie detection, memory, and legal decision-making. Section 6 concludes with brief thoughts about the future of law and neuroscience in the United States.

2 Introduction to Neurolaw in the United States

2.1 The Development of Neuroscience in Law

There are a growing number of criminal cases involving neuroscientific evidence (Snead 2006; Marchant 2008; Farahany 2011). Interest in neuroscience in the U.S. stems generally from the intersection of two things. First, the criminal and civil justice systems rely, critically and fundamentally, on the mental operations of its many participants – judges, jurors, lawyers, defendants, law enforcement officers, court officials, and witnesses. Second, new technologies enable unprecedented investigation and observation of how (and sometimes how well) those mental operations occur.

The rise of neuroscience and law follows the quite rapid and large growth of neuroscience more generally. In 1969, the Society for Neuroscience (SfN) formed with 500 members. Today, it numbers more than 40,000 and hosts an annual conference attended by more than 31,000. This 8,000% membership growth in just four decades speaks to two important facts. First, with more than 40,000 scientists studying the brain and nervous system, and a large number of them in the United States, it is clear that neuroscientific research is now front and center in labs across America. Second, the consistent and rapid *growth* of neuroscience suggests that the field is continuing on a trajectory to become even more important in the years to come.[3]

The advances in cognitive neuroscience are an enormous leap forward in understanding how minds work. Until quite recently, brain structure and function were studied separately, inasmuch as it was hard to study structure without a dead brain – and hard to study function with one. Advances in x-ray technologies opened a window on the structure of living brain tissue. But subsequent advances in techniques, such as fMRI, now enable noninvasive brain-imaging that reveals not only a person's brain structure, but also how a person's brain is (and is capable of) functioning.

The potential implications of neuroscience, for many areas of law and policy, are quite broad (Freeman 2011; Zeki and Goodenough 2006; Freeman and Goodenough 2009; Garland 2004; Annas 2007; Arrigo 2007; Farahany 2009b; Garland and Glimcher 2006; Eagleman 2008; O'Hara 2004; Patel et al. 2007; Chorvat and McCabe 2004). For example, scholars have debated both the theoretical and practical implications of neuroscience for law by addressing issues related to free will, determinism, compatabilism, and the like (see, e.g. Morse 2008b; Pardo and Patterson 2010; Greene and Cohen 2004; Nadel and Sinnott-Armstrong 2010; Erickson 2010).

In the courtroom, neuroimaging evidence has been offered in constitutional, disability benefit, and contract cases, among others. Examples include:

- *Entertainment Software Assn. v. Blagojevich* (2005) (the court considered whether a brain imaging study could be used to show that exposure to violent video games increases aggressive thinking and behavior in adolescents) and *Brown v. Entertainment Merchants Assn* (2011) (Supreme Court Justice Stephen Breyer's dissent cited "cutting edge neuroscience" to support the argument that violent video games are linked to more aggressive thinking and behavior in adolescents);
- *Fini v. General Motors Corp* (2003) (brain scans were proffered to help determine the extent of head injuries from a car accident);
- *Boyd v. Bert Bell/Pete Rozelle NFL Players Retirement Plan* (2005) (a former professional football player proffered brain scans in an effort to prove entitlement to neuro-degenerative disability benefits); and
- *Van Middlesworth v. Century Bank and Trust Co* (2000) (involving a dispute over the sale of land, the defendant introduced brain images to prove mental incompetency, resulting in a voidable contract).

Not surprisingly, neuroscience has also been offered in various criminal contexts. However, it has only been relatively recently that neuroscience has begun to appear there with increasing regularity. Here are several examples.

[3] See: Society for Neuroscience, *SfN Milestones: 40 Years of Evolution* (2009), http://www.sfn.org/skins/main/pdf/annual_report/fy2009/milestones.pdf.

Brain images are sometimes offered to help show that a defendant is incompetent to stand trial. In *United States v. Kasim* (2008), for example, Kasim introduced medical testimony and accompanying brain images to argue successfully that he was demented, and therefore incompetent to stand trial for Medicaid fraud (see also, *McMurtey v. Ryan* 2008; *United States v. Gigante* 1997).

Brain images are also increasingly proffered by the defense at the guilt-determination phase, in an effort to negate the *mens rea* element of a crime, and to thereby avoid conviction. For example, in *People v. Weinstein* (1992), the defendant argued that he was not responsible for strangling his wife and throwing her from a twelfth floor window, even if he did so. In support, he offered images of allegedly impaired brain function. Similarly, the defendant in *People v. Goldstein* (2004),[4] – who allegedly pushed a woman in front of a subway train, killing her, sought to introduce a brain image of an abnormality, in an effort to prove an insanity defense.

Brain images are also proffered at the sentencing phase of criminal cases, in furtherance of mitigation. In *Oregon v. Kinkel* (2002), for example, a boy convicted of killing and injuring fellow students in a high school cafeteria sought to introduce brain images of abnormalities, in hopes of supporting and securing a more lenient sentence. In *Coe v. State* (2000), a convicted murderer offered brain images to help prove he was not competent to be executed.

Paralleling the rise of neuroscientific evidence in criminal cases, there has been a rise in defendant's arguments – as in *Ferrell v. State* (2005) and *People v. Morgan* (1999) for instance—that a defense counsel's failure to procure a brain image amounted to ineffective assistance of counsel.

Neuroscientific evidence has also been integrated into civil litigation. For example, the term "neurolaw" was coined at least as early as 1995, when attorney J. Sherrod Taylor (1995) discussed the implications of advances in neurology for civil litigation. Since the early 1990s, a publication called *The Neurolaw Letter* has circulated among personal injury lawyers and medical professionals, and The Brain Injury Association of America has been sponsoring conferences for over two decades to bring lawyers up to speed on developments in brain science.

Across these many legal contexts, efforts to bring neuroscience into courtrooms result in a variety of distinct challenges for the legal system. We now explore some of these challenges.

2.2 The Limitations of Neuroscience in Law

Although promising, there are important methodological limitations with fMRI (Cacioppo et al. 2003; Poldrack et al. 2008; Logothetis 2008; Vul et al. 2009;

[4] *Overruled on other grounds*, 6 N.Y.3d 119, 843 N.E.2d 727, 2005 N.Y. LEXIS 3389 (2005).

Bennett et al. 2010). Many have commented on the extent to which these limitations, and those of other brain imaging techniques, may affect the probabilities of garnering legally relevant insights (Mobbs et al. 2007; Morse 2006; Pustilnik 2009; Brown and Murphy 2010; Tancredi and Brodie 2007; Rakoff 2008; Racine et al. 2005; Trout 2008; Gazzaniga 2008; Baskin et al. 2007; Uttal 2008; Uttal 2003).[5] The advance of social neuroscience generally, and legal applications in particular, has also been met with significant ethical concerns (see, e.g., Illes 2006; Farah 2002; Roskies 2008; Moreno 2003; Kennedy 2004; Uttal 2003).[6]

One of the most important critiques raised by these scholars, and recognized in court proceedings, is that there exists a long chain of inference from the fMRI scanner to the courtroom. Functional brain imaging is not mind reading (at least not in the broad sense of that term). While 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.

Because the most legally relevant thoughts are likely to be those that occurred in the past (such as those reflecting the mental state of a defendant at the time of an alleged transgression) brain scans taking place long after the behavior may be of limited diagnostic or forensic use. Even if one accepts a given scanner task as legally relevant, the particular images shown in court may still be problematic. Images can be no better than the manner in which the researcher designed the specific task or experiment, deployed the machine, collected the data, analyzed the results, and generated the images.

In addition, making individualized inferences, as law is typically required to do, from group-averaged neuroscientific data presents a particularly difficult problem for courts to overcome (Faigman 2010). For instance, just because a particular pattern of neural activity is associated, on average at the group level, with impaired decision-making, it does not necessarily follow that a defendant before the court whose brain scans produce the same neural patterns necessarily has such a cognitive deficit. As neuroscientists begin to further explore individual differences in brain activity (Hariri 2009), the "group to individual" inference problem will remain central in applying neuroscience to law.

[5] We do not review here the science of fMRI, and its many limitations, but refer interested readers to Jones et al. (2009) for an accessible discussion of the technology. For more general introductions to other cognitive neuroscience methods, see Gazzaniga et al. (2009), Ward (2009), and Purves et al. (2008).

[6] In addition, a number of websites have emerged as forums for discussing neuroethics and related bioethics issues: Dana Foundation (http://www.dana.org/); University of Pennsylvania (http://www.neuroethics.upenn.edu/); President's Council on Bioethics (http://www.bioethics.gov/); Center for Cognitive Liberty & Ethics (http://www.cognitiveliberty.org/); Stanford Center for Biomedical Ethics (http://bioethics.stanford.edu/); National Institutes of Health Bioethics Resources on the Web (http://bioethics.od.nih.gov/).

U.S. courts are still figuring out how to optimally apply evidentiary standards to novel forms of neuroscientific evidence. On the one hand, courts must ask whether there are too many faulty links in the inferential chain that leads from an fMRI scan to a relevant issue of legal responsibility. On the other hand, courts must ask whether jurors are capable of assessing, presumably with the aid of cross-examination and opposing expert witnesses, the inferential chain for themselves.

Methodological cautions, and the subsequent challenge of making appropriate legal inferences, are being acknowledged and addressed by those working at the intersection of law and neuroscience. Through publications produced by the Law and Neuroscience Project, among others, the legal community is being made aware of the many difficulties associated with introducing neuroscientific evidence. At the same time, these cautions and limitations have not, and we believe should not, prevent all use of neuroscience in courtrooms and policymaking. Rather, what is called for is careful, context-specific applications.

3 Evidentiary Context

The methods, goals, and evidentiary standards differ for neuroscience and law (Jones 2004; Sapolsky 2004; Schauer 2010). And, even within law, policymakers see the value in different standards of proof when different interests are at stake (Faigman 2002). Thus, we caution at the outset that how, if at all, the legal system integrates neuroscientific evidence will, and should, vary context by context.

To date, neuroscientific evidence has appeared in the form of expert testimony about the brain, from researchers and clinicians, as well as in the form of graphic images produced through methods such as fMRI, electroencephalography (EEG), qEEG, and others. The novel applications of new brain imaging and brain monitoring technologies have created many practical problems for judges in the U.S., as they consider the admissibility of such evidence, its proper interpretation, its impact on jurors, and the like (Greely and Wagner, Forthcoming; Sinnott-Armstrong et al. 2008; Moriarty 2008; Aharoni et al. 2008; Rogers and DuBois 2009; Pettit 2007).

At present, the admissibility of neuroscientific evidence in U.S. courts remains fluid, and is highly contextual. Even if we limit our focus solely to the federal system, the admissibility of neuroscientific evidence will still vary with the specific legal context in which the brain evidence arises.[7]

[7] Given the institutional design of the United States criminal justice system, the admissibility of neuroscientific evidence will not be uniform across the country. This is because the United States has multiple, overlapping criminal jurisdictions (Barkow 2011). Local, state, and federal authorities can all bring criminal charges (Barkow 2011; Stuntz 2008). Of particular note for understanding the admissibility of neuroscientific evidence is that the evidentiary rules that apply in the federal system may be different than those that apply in each of the 50 state systems. While there are many similarities across the 50 states, each state criminal code is unique and each state crafts, within Constitutional limits, its own admissibility standards for scientific evidence. Thus, it

In the civil system, for example, neuroscientific evidence might be introduced to help establish liability, such as in the case of a medical malpractice action; to demonstrate a pre-existing condition, such as in the case of a dispute over insurance coverage; or to help estimate damages, such as in the case of a car accident.

In the criminal system, brain evidence may be offered during the liability phase, the sentencing phase, or both. For example, during the liability phase, the defense may offer brain evidence to support an insanity defense, or to defeat the prosecution's claim that the defendant had (and was therefore capable of having) the mental state requisite for conviction, or to provide evidence of truthfulness. During the sentencing phase, brain evidence may be offered to support a mitigated penalty.

At the liability/guilt stage, the admissibility of neuroscientific evidence in the U.S. is governed by rules that are used to assess scientific evidence generally (Faigman et al. 2011).[8] In the federal system, courts primarily apply Federal Rule of Evidence 702 (allowing an expert witness to testify "if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case"), and Federal Rule of Evidence 403 (allowing for the exclusion of relevant evidence "if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury"). Application of Rule 702 is guided by a trilogy of U.S. Supreme Court cases delivered in the 1990s (Saks 2000; *Daubert v. Merrell Dow Pharmaceuticals, Inc.* 1993; *General Electric Co. v. Joiner* 1997; *Kumho Tire v. Carmichael* 1999).[9]

How will U.S. federal courts apply the *Daubert* standards to neuroscientific evidence? While the answer, as we have stressed, will vary across contexts, we can gain purchase on this question by reviewing the 2010 case *United States v. Semrau*, in which the first *Daubert* hearing was held on the admissibility of fMRI lie-detection evidence (Shen and Jones 2011).[10] In *Semrau*, the federal government charged psychologist Dr. Lorne Semrau with Medicare/Medicaid fraud. Proving fraud required proving that Semrau knowingly violated the law. And Semrau's defense was built, in part, around fMRI scans that allegedly demonstrated he was telling the truth when he claimed (some years after the fact) that even though he had mis-billed for services, he did not *knowingly* defraud the government.

should be kept in mind that although we discuss (for brevity) only the Federal rules, in practice neuroscientific evidence will be evaluated by many different standards.

[8] It is noted by commentators that scientific evidence, such as fMRI, may be offered to prove an "adjudicative fact" (e.g., determining mental capacity or for diagnosing a brain injury), or to prove a "legislative fact" (e.g., that there is a general relationship between exposure to violent video games and aggressive behavior) (Feigenson 2006; Davis 1942).

[9] At the state level, some states have adopted the *Daubert* approach; some states still rely primarily on a general acceptance test based on *Frye v. United States* (1923); and some states have blended the two.

[10] Our discussion of the *Semrau* case here is derived, in part, from Shen and Jones (2011).

In assessing the reliability of the proffered fMRI evidence, the Court's analysis applied the previously mentioned *Daubert* test and considered four, non-exclusive factors[11]:

1. Whether the theory or technique can be tested and has been tested;
2. Whether the theory or technique has been subjected to peer review and publication;
3. The known or potential rate of error of the method used and the existence and maintenance of standards controlling the technique's operation; and
4. Whether the theory or method has been generally accepted by the scientific community.

The judge found that factors 1 and 2 were satisfied, while factors 3 and 4 were not. He therefore concluded that the evidence was not admissible under Rule 702.

While the *Semrau* case is illustrative for how U.S. courts might apply evidentiary standards, the case is not necessarily instructive on the future of fMRI (and related brain) evidence in U.S. courts. To begin with, other types of neuroscientific evidence (e.g., brain scans in civil brain injury cases) are often admitted. Moreover, in *Semrau* the evidence was offered at the liability/guilt stage, where the Federal Rules and *Daubert* apply.

In the sentencing phase, however, the evidentiary rules are relaxed and "the court may consider relevant information without regard to its admissibility under the rules of evidence applicable at trial, provided that the information has sufficient indicia of reliability to support its probable accuracy" (Federal Sentencing Guidelines, §6A1.3. Resolution of Disputed Factors). This difference in evidentiary standards is in part, as we will see in the next section of this chapter, why neuroscientific evidence has featured more prominently in the sentencing rather than liability/guilt phase of criminal trials.

Even at the guilt phase, sufficient progress in the underlying science may allow for admissibility. In *Semrau*, the judge wrote in a footnote that "in the future, should fMRI-based lie detection undergo further testing, development, and peer review, improve upon standards controlling the technique's operation, and gain acceptance by the scientific community for use in the real world, this methodology may be found to be admissible even if the error rate is not able to be quantified in a real-world setting."[12] The future admissibility of fMRI evidence in U.S. courts remains very much an open question.

As the use of brain imaging and brain monitoring techniques grows, so too will Constitutional concerns about their use in the legal system. The ability to image the brain while it is thinking raises new questions about what has been variously

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[11] In evaluating the admissibility of the evidence, the federal judge performed a two-prong gatekeeping role for expert scientific evidence, first evaluating the reliability and then the relevance of the testimony. Because the Court did not find the proffered testimony in Semrau to be reliable, it did not reach the relevance prong.

[12] *United States v. Semrau,* Report & Recommendation, p. 31 (2010).

described as, “cognitive privacy,” “cognitive liberty,” and “cognitive freedom” (Blitz 2010; Tovino 2007b; Halliburton 2007). At issue are the protections offered by the U.S. Constitution against state use of brain imaging on an unwilling or unaware citizen (Fox 2009; Greely 2004; Tovino 2005).

One crucial question is whether a brain scan is “testimonial” (e.g., forced confession) or “physical” (e.g., fingerprints, handwriting samples, blood tests) evidence (Fox 2009). The 3-prong test to invoke self-incrimination protections are: (1) compulsion, (2) incrimination, and (3) testimony. The first two prongs presumably would be met by a nonvoluntary brain scan, but whether an fMRI scan is testimonial or physical evidence is not yet resolved, and the characterization determines the legal implications. In addition, 4th Amendment protections against search and seizure, and 5th Amendment protections against compelled testimony may also arise in the context of brain fingerprinting (Halliburton 2007; New 2008; Taylor 2006).

4 Neuroscience and Criminal Law

In this section, we very briefly review the role that neuroscientific evidence has played in the U.S. criminal justice system.[13] As earlier, we continue to distinguish between neuroscientific evidence used at the liability/guilt phase and at the sentencing phase. Rarely, it seems, will neuroscientific evidence alone determine culpability. At the sentencing phase, however, neuroscientific evidence is already contributing, and may continue to contribute, to the determination of sentences and treatment.

We also discuss the important implications of neuroscientific evidence for several special populations within the justice system: adolescents, addicts, and trauma victims. For all three populations, there is evidence that – especially at the policy level – the legal system is recognizing that brain differences between these groups and the normal population may recommend differences in sentencing.

4.1 Neuroscience and Culpability

Criminal responsibility in the United States can be summarized in this way:

> Crimes are defined by their “elements,” which always include a prohibited act and in most cases a mental state, a *mens rea*, such as intent. The Constitution’s Due Process Clause has been construed to require that the prosecution must prove all the elements defining a criminal offense beyond a reasonable doubt. Even if the state can prove all the elements beyond a reasonable doubt, the defendant may avoid criminal liability by establishing an affirmative defense of justification or excuse. (Morse and Hoffman 2007, p. 1074).

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[13] Because of the United States’s federal system, each of the fifty states can, within Constitutional limitations, set its own *mens rea* requirements. As we did in discussing evidentiary standards, we will focus here solely on the federal system.

Culpability of the accused thus depends, in part, on a determination of his/her mental state at the time of the offense. The phrase "mens rea" ("guilty mind") derives from the Latin phrase "*Actus non facit reum nisi rea sit*," which means "An act is not guilty unless the mind is guilty." While virtually all crimes require a guilty mind, the type of intent required varies. Some crimes simply require "general intent," while others, either expressly or impliedly, contain a "specific intent" *mens rea* requirement.

Although as a practical matter it is now extremely rare to succeed with such a defense, one important avenue by which defendants may avoid liability is by proving "legal insanity." One method for assessing sanity, and the test now used by most state and federal courts, is to examine the defendant's "cognitive" ability, at the time of the crime, to know, appreciate, and understand that the conduct he was engaging in was morally or legally wrong. An alternative, now less common, method is to employ a "control" test, asking whether the defendant could control his conduct in conformity with the law. After John Hinckley was acquitted in 1982 by reason of insanity, following his attempted assassination of President Ronald Reagan, the U.S. Congress and most states reacted by eliminating the control test and relying solely on the cognitive test. (Incidentally, Hinckley's defense introduced computed tomography X-ray evidence in support of its claim of Hinckley's brain abnormalities.)

Some have argued that neuroscientific evidence provides reason to push back against this shrinking insanity defense (Sapolsky 2004; Redding 2006). Neuroscientist Robert Sapolsky has provocatively argued that the legal system should, in light of what has been learned about the effects of damage to the prefrontal cortex (PFC), rebut its presumption of responsibility and instead recognize a continua of individual capacity to regulate self-control. Sapolsky (2004, p. 1794) argues that "although it may seem dehumanizing to medicalize people into being broken cars, it can still be vastly more humane than moralizing them into being sinners." Similarly, law professor Richard Redding (2006) has argued for a new neurojurisprudence that would reform the insanity defense in light of neuroscientific findings.

Thus far, these latter policy suggestions regarding the insanity defense have not materialized, and it remains rare for defendants to mount a successful insanity defense. The introduction of neuroscientific evidence seems unlikely to alter this state of affairs. To illustrate, one of the earliest and most prominent cases of brain imaging evidence used at the liability/guilt phase was the 1992 case of Herbert Weinstein. Weinstein strangled his wife and threw her out the window of their apartment in an effort to make the murder look like a suicide (*People v. Weinstein* 1992; Rojas-Burke 1993). Weinstein admitted to his actions, but mounted an insanity defense that included positron emission tomography (PET) evidence showing the presence of an arachnoid cyst that, Weinstein argued, had impaired his ability to reason (Relkin et al. 1996). Although Weinstein pled out his case, and went on to serve many years in prison, the judge's admission of the PET evidence drew much attention and critique in the legal and scientific communities (Martell 1996; Morse 1996; Weiss 1996; Denno 2002).

The prosecutor in the case predicted that, with *Weinstein*, "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" (Weiss 1996, p. 202). Nonetheless, in the 20 years since the Weinstein case was decided, neuroimaging evidence has rarely been used successfully by defendants to avoid convictions. This is because, as Stephen Morse (2006) has pointed out, the U.S. legal system establishes criminal responsibility based on behavior, not brain states. Put simply, "brains do not commit crimes; people commit crimes" (Morse 2006, p. 397). In the United States, neuroscientific evidence has thus far been, and most likely will continue to be, only minimally useful in exculpating criminal defendants.

4.2 Neuroscience and Sentencing

While the prospects for successful "my brain made me do it" defenses seem slim, neuroscientific evidence is already having a significant mitigating impact in some cases at the sentencing phase. There remains, however, much disagreement over how brain evidence should be interpreted.

We earlier quoted a juror in the *Nelson* case, stating that the qEEG evidence presented was persuasive. But other jurors disagreed. For example, one remarked that "all that testimony, that was a waste of taxpayer money. That's phony. There's nothing wrong with that guy's brain." (Ovalle 2010, p. 1). The net effects of neuroscientific evidence on sentencing decisions remain unknown.

One particularly important sentencing context in which neuroscientific evidence has been used is in death penalty cases. Sentencing procedures for civilian capital cases are governed by federal law and allow the Court to consider both mitigating and aggravating factors. Using neuroscientific evidence in capital sentencing, however, introduces a double-edged sword problem that multiple commentators have recognized (Snead 2007; Farahany and Coleman 2009; Barth 2007). That is, a brain *too* broken may be simply too dangerous to have at large, even *if* it is somehow less culpable.

Neuroscientific evidence may also be used in other types of challenges to the death penalty. For instance, Farahany (2009a) argues that when the U.S. Supreme Court outlawed the death penalty for mentally retarded capital offenders (*Atkins v. Virginia* 2002), the Court created a new type of inequality because it did not protect similarly situated individuals who – by virtue of a traumatic brain injury suffered as an adult – have the same limits in cognitive and behavioral ability as those medically diagnosed as mentally retarded. Thus, Farahany suggests that a challenge may be ripe under the equal protection guarantees of the 14th Amendment of the U.S. Constitution.

One emerging, but not yet fruitful, area in which neuroscience may play a sentencing role is in the assessment of future dangerousness (Nadelhoffer et al. 2010; Beecher-Monas and Garcia-Rill 2003). Neuroscientist Kent Kiehl, with support from the *Law and Neuroscience Project*, is conducting the first study that may provide traction for brain-based neuroprediction. A number of risk assessment tools, based on a battery of behavioral data, are currently used in the criminal justice system (Monahan 2006). If incorporating brain scan data into these future dangerousness assessments improves the predictive power of actuarial models it may have important implications in at least three sentencing contexts: (a) capital sentencing; (b) civil commitment hearings; and (c) detention hearings for so-called "sexual predators" (Nadelhoffer et al. 2010).

4.3 The Adolescent Brain

Roughly a century ago, Progressive Era reformers in the United States created separate juvenile courts in the hopes that such courts would allow for better youth rehabilitation (Scott and Steinberg 2008). Toward the end of the twentieth century, however, in response to growing juvenile crime rates, juvenile courts became more punitive and state legislatures allowed for juveniles to be more readily transferred to the adult system (Id.). Today, both the states and the U.S. Supreme Court are reexamining juvenile justice policies. This is happening at a time when the developmental neuroscience of adolescent behavior is beginning to offer important legally relevant insights (Baird 2009). And neuroscience appears to be playing some modest role in affecting legislative enactment and Supreme Court deliberations (Haider 2006; Scott and Steinberg 2008; Maroney 2010).[14]

Two U.S. Supreme Court cases are most prominently discussed: *Roper v. Simmons* (2005) and *Graham v. Florida* (2010). In *Roper*, the Court, with Justice Kennedy writing for the majority, ruled 5–4 that the 8th and 14th amendments of the Constitution prohibited the death penalty for those who were under 18 years of age when committing a capital crime. In *Graham*, the Court, with Justice Kennedy again writing for the majority, ruled 6–3 that it is unconstitutional under the 8th and 14th amendments of the Constitution for juveniles to be sentenced to life in prison without parole for nonhomicide crimes.

In both cases, the Court received numerous "amicus briefs." An amicus brief, which gets its name from the Latin *amicus curiae* (meaning "friend of the court"), is a brief submitted to the Court by individuals or organizations who are not parties to the case. In *Roper*, more than 15 amicus briefs were filed, and more than 20 were filed in *Graham*. Several of these briefs, including the ones submitted by the

[14] More generally, U.S. society is now being exposed to explicitly brain-based advertisements related to the developing brain. An ad created by the All-State Insurance company features an illustrated brain, sitting on a pedestal labeled "16-year-old brain". One area of the brain is missing, and the ad reads: "Why do most 16-year-olds drive like they're missing a part of their brain? Because they are." The ad, which encourages readers to contact their legislators and support Good Driving Laws, is illustrative of the ways by which brain-based evidence may affect society and policymaking even outside of the court system. See: http://www.allstate.com/content/refresh-attachments/Brain-Ad.pdf.

American Medical Association and American Psychological Association, touched upon the relevance of neuroscience and psychology research on juveniles.

In *Graham*, both the majority and dissenting opinions discussed, in part, the underlying science of adolescent development. The majority opinion explicitly referred to brain science (Section III.B, p. 17):

> No recent data provide reason to reconsider the Court's observations in *Roper* about the nature of juveniles. As petitioner's *amici* point out, developments in psychology and brain science continue to show fundamental differences between juvenile and adult minds. For example, parts of the brain involved in behavior control continue to mature through late adolescence. See Brief for American Medical Association et al. as *Amici Curiae* 16–24; Brief for American Psychological Association et al. as *Amici Curiae* 22–27.

To be sure, the dissents in *Roper* and in *Graham* interpreted the research differently. In *Roper*, for instance, Justice Scalia dissented that "Given the nuances of scientific methodology and conflicting views, courts—which can only consider the limited evidence on the record before them—are ill equipped to determine which view of science is the right one" and that "At most, these studies conclude that, *on average*, or *in most cases*, persons under 18 are unable to take moral responsibility for their actions. Not one of the cited studies opines that all individuals under 18 are unable to appreciate the nature of their crimes."

Scholars continue to actively debate the role that neuroscience research on adolescent brains does, and should, have in these and related cases (Maroney 2010; Morse 2006; Aronson 2007; Aronson 2009; Katner 2006; Gruber and Yurgelun-Todd 2006; Droback 2006). And so, as in other areas of neurolaw, the future of law and the developing brain remains uncertain.

4.4 Addiction, Trauma, and Responsibility

Central to debates about how the criminal justice system should deal with addicted criminals is the extent to which addiction is considered a brain disease (Bonnie 2002). In 1962, the U.S. Supreme Court ruled that a California statute making the status of drug addiction a punishable offense was cruel and unusual punishment under the 8th and 14th Amendments (*Robinson v. State of California* 1962). In arriving at its decision, the court analogized drug addiction to being mentally ill or having a venereal disease. In 1968, however, the Court ruled that states could punish alcoholics for being drunk in public (*Powell v. State of Texas* 1968). In general, addiction is not recognized as a valid defense to criminal behavior (Bonnie 2002). At sentencing, however, addiction may play some role in mitigation.

Two competing visions, echoing the debate over the neuroscience of legal responsibility more generally, present themselves in the face of neuroscience research on addiction:

> As we learn more about . . . the neurobiological substrates that underlie voluntary actions, how will society define the boundaries of personal responsibility in those individuals who have impairments in these brain circuits? . . . At present, critics of the medical model of addiction argue that this model removes the responsibility of the addicted individual from

> his/her behavior. However, the value of the medical model of addiction as a public policy guide is not to excuse the behavior of the addicted individual, but to provide a framework to understand it and to treat it more effectively (Volkow and Li 2004, p. 969).

Neuroscience, to the extent that it can improve treatment programs, may play an increasing role in specialized U.S. "problem solving" courts, which have emerged in the past two decades, and which now include specialized courts for drug treatment and drug reentry for addicts leaving prison (Hora and Stalcup 2008). As of June 2010, more than 2,500 drug courts were in operation, with at least one in every U.S. state and territory.[15] Addressing addiction in the criminal justice system remains a challenge. Substance-involved inmates accounted for 85% of all incarcerated offenders in federal, state, and local jails in 2006.[16] More than 20% of inmates for violent crimes were under the influence of alcohol when acting violently; more than 40% of first-time offenders have a drug use history; and more than 80% of those with five or more convictions have a history of drug use.[17]

Against this backdrop, advances in our understanding of the neurobiology of addiction may allow courts, and legal actors throughout the justice system, to improve upon the folk psychological explanations for behavior that, at best, are incomplete and, at worst, are counter to prevailing scientific consensus.

In addition to drug addicts, military veterans have also received special attention in the legal system. Modeled after the drug courts, new courts have been created in some states, over the past 5 years, to determine sentences for combat veterans (Russell 2009; Hawkins Hon 2010). These courts raise questions about how, if at all, wartime trauma – or indeed non-wartime trauma – should factor into criminal responsibility (Hafemeister and Stockey 2010; Meszaros 2011).

4.5 Psychopathy

Psychopathy is a personality disorder marked by emotional detachment and antisocial behavior (Weber et al. 2008; Kiehl 2008), and is most frequently diagnosed using the Hare Psychopathy Checklist-Revised (PCL-R). Psychopathy is relevant to law because, while estimated to affect just 1% of the adult male population, it is estimated that psychopaths make up 25% of the adult male prison population (Kiehl 2006). Psychopaths account for a disproportionate percentage of the country's violent crime (Kiehl and Hoffman Forthcoming).

The U.S. legal system does not recognize psychopathy as an excusing condition (Morse 2008a). Moreover, the Model Penal Code, which is influential as a model in most states, though not binding, specifically excludes psychopathy as sufficient for

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[15] See: National Association of Drug Court Professionals, http://www.nadcp.org/learn/what-are-drug-courts/history.

[16] National Center on Addiction and Substance Abuse at Columbia University (2010). *Behind Bars II: Substance Abuse and America's Prison Population*. NCJ 230327.

[17] Petersilia (2003), p. 48.

establishing an insanity defense. That said, in at least one prominent case (reported in Hughes 2010) brain evidence may have given a jury pause in delivering its sentence to a psychopathic killer.

While legal doctrine may or may not ultimately change in light of neuroscientific studies of psychopathic brains, this will not prevent the parallel development of better treatment programs for psychopathy. It is promising that at least some treatment programs have reported and replicated findings of reduced likelihood of recidivism in a population of violent male adolescents (Caldwell et al. 2006, 2007).

5 Neuroscience and Tort Law

Legal scholarship at the intersection of law and neuroscience, with a few notable exceptions (e.g., Kolber 2007; Kolber 2011; Grey 2011; Viens 2007; Shen 2010), has focused primarily on the criminal justice system. There is also good reason, however, to focus on the civil side. In this section, we examine two ways in which neuroscience intersects with important components of tort law: (1) litigation over brain injury, and (2) litigation over emotional harms.

5.1 Brain Injury

Law and the brain sciences have a longstanding, if at times contentious, relationship in civil litigation over brain injuries. Perhaps, the most difficult hurdle to overcome in civil litigation is that of causation (Smith 2009). In order to successfully recover monetary damages, a plaintiff must not only demonstrate an injury, but also that the defendant's actions (or inaction) caused the injury (Young et al. 2006). This is often difficult to do in the case of brain injuries because there is typically no data on the state of the brain prior to an alleged tortious incident. In this way, the causation conundrum is as difficult to resolve as the complex criminal responsibility issues raised earlier.

Despite these challenges, litigation over brain injuries remains common. In recent years, there has been great interest in cases of Traumatic Brain Injury (TBI), and the related mild Traumatic Brain Injury (mTBI). This type of litigation has gained prominence through high-profile investigations into the relationship between concussions and brain damage in American football players (Kluger 2011). Hundreds of individual law suits are already in progress, and the National Football League also faces a class action lawsuit from players who have suffered brain injuries (Schwarz 2010; Borden 2011).

5.2 Pain and Emotional Harm

A second part of civil litigation in which neuroscience may increasingly play a role is in the determination and valuation of pain (Viens 2007). The subjectiveness of pain makes it difficult for the law to determine (a) who is actually feeling pain (as opposed to simply faking it), and (b) how much pain an individual is experiencing (Kolber 2007). Brain imaging, although it is not yet fully capable of doing so, offers at least the promise of providing more objective measures of pain than are presently available (Id.).

Posttraumatic stress disorder (PTSD) provides a useful illustrative case. It has been observed that "No diagnosis in the history of American psychiatry has had a more dramatic and pervasive impact on law and social justice than PTSD."[18] PTSD litigation remains prevalent in the U.S. today. Scientists are beginning to better understand the neural correlates of PTSD, as distinct from other similar mental disorders (Grey 2011). Such advances could, if they materialize as promised, fundamentally change PTSD litigation.

Neuroscience might also change litigation over PTSD, and related mental harms, by changing the way we conceptualize such harms. Traditionally, the U.S. system draws a bright line distinction between "bodily" versus "mental" (i.e., *non*-bodily) harms (Grey 2011; Shen 2010). But in at least one instance – a case that went up the Michigan state supreme court before settling – neuroscience evidence has been advanced to argue that PTSD is in fact a "bodily" injury (*Allen v. Bloomfield Hills School District* 2008).

In the *Allen* case, affidavits submitted to the court on the plaintiff's behalf included neuroscientific evidence, and although the trial court sided with the defense (which argued that proper statutory interpretation did not include PTSD as bodily), the Appellate Court ruled in favor of Allen, reasoning that: "The 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' . . .plaintiff presented objective medical evidence that a mental or emotional trauma can indeed result in physical changes to the brain."[19] The ruling has no precedential weight, but is a stark reminder of the breadth of neuroscience and law litigation that we may see in the coming years.

6 Special Topics

6.1 Lie Detection

Despite the fact that its short-term prospects for admissibility are dim, and its scientific validity remains in doubt, neuroscience-based lie detection has received considerable attention in both scientific and legal outlets (Wagner 2010; Ganis and Keenan 2009; Bizzi et al. 2009; Schauer 2010; Shen and Jones 2011; Appelbaum 2007; Sip et al. 2007; Wolpe et al. 2005; Greely and Illes 2007; Simpson 2008; Moriarty 2009; Alexander 2006; Stoller and Wolpe 2007).

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[18] Stone (1993), p. 23.

[19] *Allen v. Bloomfield Hills* (2008), p. 57.

At present, there is a consensus in U.S. scientific circles that brain-based lie detection is not ready for legal use. As neuroscientist Anthony Wagner (2010, p. 14) concluded, in a comprehensive 2010 review of the literature, "there are no relevant published data that unambiguously answer whether fMRI-based neuroscience methods can detect lies at the individual-subject level."

Despite the scientific limitations, there are still several instances in which fMRI and EEG-based lie detection evidence have been proffered in U.S. courts. In 2003, an Iowa state court admitted EEG-based "brain fingerprinting" lie-detection evidence (*Harrington v. State* 2003; see Greely and Illes 2007, p. 387–388). The neuroscientific testimony was not considered directly on appeal in the *Harrington* case, but the case nonetheless drew national attention for the very fact that such evidence had been admitted.

In *Wilson v. Corestaff* (2010), a plaintiff in a New York state court sought an evidentiary hearing on the admissibility of fMRI lie-detection evidence to bolster the credibility of a key witness. The judge found that "since credibility is a matter solely for the jury and is clearly within the ken of the jury . . . no other inquiry is required." Such a response is consistent with a U.S. Supreme Court decision in which Justice Clarence Thomas wrote that "a fundamental premise of our criminal trial system is that 'the jury is the lie detector'" (*United States v. Scheffer* 1998, p. 313).

When courts encounter neuroscience-based lie-detection evidence in the future, they are likely to arrive, as the court did in *Semrau* (discussed earlier, in Section 2) at the question of whether novel neuroscientific-based lie-detection technologies are analogous to, or distinguishable from, their polygraph predecessors. Although the polygraph is routinely used in police investigations and in employee screening in some federal agencies (National Research Council 2003), the polygraph is almost uniformly inadmissible in state and federal courts (Greely and Illes 2007). Proponents argue that fMRI is a reliable proxy of brain activity and is not readily susceptible to effective counter measures. Opponents contend that fMRI lie detection is just as unreliable as the polygraph, and therefore should be excluded from evidence.

The future of neuroscientific lie detection will hinge not only on legal analogy, of course, but also on scientific progress. In addition to two private U.S. firms – No Lie MRI and Cephos Corporation – scholars are working on novel neuroscientific approaches to detecting deception. Greene and Paxton (2009), for instance, devised an experimental protocol that did not rely, as previous experiments had, on an instructed lie.

6.2 Memory

Neuroscience and psychology have taught us much about how human memory systems function (Milner et al. 1998; Squire 2004). Memory researchers have pointed out the deficiencies and complexity of human memory (see, e.g. Schacter 2002; Schacter and Slotnick 2004). We know, for instance, that we are susceptible to false memories (Loftus 2005; Bernstein and Loftus 2009); that we forget much of what we experience (Wixted 2004); that emotional state affects the quality of our memories (Phelps 2004); and that our personal experience can affect how we remember an event (Sharot et al. 2007; Kensinger and Schacter 2006).

At the same time, we know that memory and law are intimately intertwined. From police lineups and questioning of suspects at the start of a case, to eye witness testimony and jury recollection of trial material at the end of a case, memory is implicated at every stage of legal proceedings. Courts, then, are faced with an intractable problem: human memory is flawed, yet adjudication by nature must typically rely on it.[20] What are courts to do? And can neuroscience help?

Neuroscience research on memory, over and above the general increase in knowledge it offers the legal system, may one day generate tools for courts to distinguish between real and false memories. For instance, work underway in the laboratory of neuroscientist Anthony Wagner is making progress on the detection of real-world, autobiographical memories (Rissman et al. 2010).

Memory detection using neuroscientific tools also raises new constitutional and ethical considerations (Fox 2008; Kolber 2006). For instance, how strong are our rights to privacy with regard to our memories? What constitutional protections exist to prevent the state from taking a "fingerprint" of one's brain? In what contexts should individuals be allowed, or ever forced, to alter (as through existing memory-altering drugs, for instance) their memories? Questions such as these were debated by the President's Council on Bioethics (2003) and continue to be an active topic for debate.

6.3 Legal Decision-Making

The cognitive shortcoming of participants in the legal system has been well researched (see, e.g., Simon 2011). Cognitive neuroscience builds upon this psychology literature to provide us with new insights into the processes by which judges, jurors, and attorneys arrive at the decisions they make (Knabb et al. 2009; Goodenough 2001). Neuroscience research on moral and legal decision-making has begun uncovering the neural correlates of a number of important aspects of legal decision-making (e.g., Young et al. 2010; Koenigs et al. 2007; Schleim et al. 2010; Borg et. al. 2006; Buckholtz et al. 2008), such as the brain activity underlying the decisions of whether to punish someone and, if so, how much (Buckholtz et al. 2008).

[20] One option, often rejected by courts, is to allow an expert witness to testify to the limitations of memory. In rejecting this option, courts may point out that it is the purpose of the jury to make its own estimation of the reliability of the witness' memory (*United States v. Rodriguez-Berrios* 2009).

In addition to these neuroimaging studies, a growing body of psychology and neuroscience research suggests that, when making moral judgments, we are guided by our automatic, evolved emotional responses (Greene and Haidt 2002; Haidt 2001). Numerous scholars are therefore exploring how emotions, across a variety of legal contexts, affect moral and legal reasoning (Salerno and Bottoms 2009; Kahan 2008; Posner 2000; Maroney 2006; Jones 1999; Abrams and Keren 2010; Weinstein and Weinstein 2005; Berman 2008).

It is also important to consider the effects of neuroscientific evidence on juror decision-making. While some early empirical work suggested that the "seductive allure" of brain images would unduly persuade jurors (Weisberg et al. 2008; McCabe and Castel 2008), a more recent and much more robust set of studies suggests just the opposite: relative to other scientific evidence that would be admitted in its place, this research suggests that there is no significant relationship between the introduction of brain imaging evidence, per se, and punishment or blame outcomes (Schweitzer et al 2011; Schweitzer and Saks 2011). Other studies find that the effects of fMRI lie detection evidence may be nullified by cross-examination (McCabe et al 2011).

7 Conclusion

Neuroscientific evidence is increasingly reaching U.S. courtrooms in a number of legal contexts, and this trend is likely to continue for the foreseeable future. The emerging field of law and neuroscience is being built on a foundation joining: (a) rapidly developing technologies and techniques of neuroscience; (b) quickly expanding legal scholarship on implications of neuroscience; and (c) (more recently) neuroscientific research designed specifically to explore legally relevant topics. With the institutional support of many of the country's top research universities, as well as the support of the MacArthur Foundation, among other private foundations and public funding agencies, the U.S. is well positioned to continue contributing to international developments in neurolaw.

In this chapter, we have provided a very brief overview of neurolaw developments in the United States. We did not, of course, reach every facet. And topics omitted here include implications of neuroscience for determinations of brain death, mental health law, intellectual property, consumer law, and employment law (Tovino 2007a), as well as issues surrounding appropriate regulation of neuroimaging for legal and national security purposes (Kulynych 2007; Marks 2007). We are also unable to do justice, in these brief pages, to numerous ethical questions that neurolaw can raise (see, e.g. Illes and Sahakian 2011, Illes 2003; Illes 2006; Farah 2005; Moreno 2003; Roskies 2002; Gillet 2009; Greely 2006), such as those related to the possibility of medical findings incidental to research purposes (Wolf et al. 2008; Richardson 2008; Miller et al. 2008), or those sparked by the possibility of cognitive neuro-enhancement (Farah et al. 2004; Greely et al. 2008). Nonetheless, and in summary, several factors are likely to lead to the continued growth of law and neuroscience in the U.S.

First, legal scholars are demonstrating great interest in expanding the dialogue between law and neuroscience. Evidence from the *Law and Neuroscience Bibliography* suggests that there has been incredibly strong growth in 2008 and 2009 in the annual number of articles published per year on law and neuroscience.[21] The 127 publications in 2009 represents a 300% increase over the number published just 5 years earlier, and represents a 2,000% increase over the number published a decade before. Related scholarly communities, such as the Society for Evolutionary Analysis in Law, are similarly strengthening ties between the legal and scientific communities.[22] These trends suggest that future years will bring continued expansion of interdisciplinary scholarly collaboration.

Second, a practical constraint thus far to expanded use of neuroscientific evidence is the prohibitive costs of brain scanning. To the extent that the costs of fMRI and other neuroscientific technologies drop significantly in the coming years, as brain scanning facilities continue quick proliferation, resource limitations will decline as a barrier to entry – both for researchers and for litigants.

Third, practicing lawyers have also shown increasing interest in improving their professional skills through advances in the mind sciences. Books have been published for a practitioner audience (see, e.g., Sousa 2009; Uttal 2008), and Continuing Legal Education classes have been offered as well. Some of these works are optimistic about prospects for legal applications; others sound cautionary notes. Together, they are continuing to capture the attention of key segments of the practicing bar.

If, as we anticipate, the field of law and neuroscience expands, it will require new training for judges. Already a significant number of judges in the United States are being introduced to neuroscience. Since 2007, for instance, the *Law and Neuroscience Project* has partnered with the Gruter Institute for Law and Behavioral Research, the Federal Judicial Center (FJC) and the National Judicial College (NJC) to sponsor major conferences for hundreds of U.S. judges. (The FJC is the research and education agency of the U.S. federal judicial system; The NJC offers an average of 90 courses annually with more than 2,000 judges enrolling from all 50 states.) And the American Association for the Advancement of Science (AAAS) has also sponsored numerous programs for judges. The topics covered at the conferences included, among other things, an introduction to neuroscience; presentations on frontal lobe function including decision-making, behavioral control, and counter-factual thinking; and presentations on measuring individual variation and subjective states including lie detection, pain assessment, and punishment. The indirect effects of these efforts are much larger, as judges who attend the conferences share information with their colleagues on the bench.

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[21] The bibliography is available online at: http://www.lawneuro.org.

[22] For more information on the Society for Evolutionary Analysis in Law (SEAL), see: http://www.sealsite.org.

U.S. legislators too may play an important role in shaping the future of neurolaw. Some state legislators have already held committee hearings about neuroscience findings. And in the case of early-childhood legislation, for example, Washington State legislator Ruth Kagi (D-WA) credited neuroscience for finally allowing her bills on the issue (which she had been proposing for nearly a decade) to pass. Representative Kagi noted in a 2007 speech that after hearing neuroscientific testimony, a political opponent, "who had stopped every piece of early childhood legislation in the past 5 years, came up to me and said, '*I get it*.'"[23] In addition, a New York state legislator in 2009 proposed a bill that would make certain MRI scans inadmissible in criminal proceedings.

As judges, lawyers, legislators, legal scholars and the public become more acquainted with neuroscientific evidence, and as neuroscience continues to produce more legally relevant findings, it is likely that we will see continued expansion of law and neuroscience in the United States.

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