Law and Cognitive Neuroscience

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Abstract

Law and neuroscience (sometimes neurolaw) has become a recognized field of study. The advances of neuroscience are proving useful in solving some perennial challenges of legal scholarship and are leading to applications in law and policy. While caution is appropriate in considering neurolaw approaches, the new knowledge should—and will—be put to use. Areas of special attention in current neurolaw scholarship include (*a*) techniques for the objective investigation of subjective states such as pain, memory, and truth-telling; (*b*) evidentiary issues for admitting neuroscience facts and approaches into a court proceeding; (*c*) free will, responsibility, moral judgment, and punishment; (*d*) juvenile offenders; (*e*) addiction; (*f*) mental health; (*g*) bias; (*h*) emotion; and (*i*) the neuroeconomics of decision making and cooperation. The future of neurolaw will be more productive if challenges to collaboration between lawyers and scientists can be resolved.

Neurolaw: the combined study of law and neuroscience

Cognitive neuroscience: the study of thought and behavior informed by the discoveries of neuroscience about the physical nature of brain processes

INTRODUCTION

Over the past few years, neurolaw has become a recognized field of study. Law is an inveterate intellectual scavenger from advances in other fields (Elliott 1985). The very existence of this publication, *The Annual Review of Law and Social Science*, corroborates law's omnivorous taste for interdisciplinary knowledge. The explosive spread of new knowledge flowing from cognitive neuroscience makes the development of neurolaw inevitable.

Of course, law has implicitly considered issues of thought and behavior, at least naively, for centuries. Law must work with and within the human brain to govern behavior and structure society, and as the law's cognitive fit improves, its effectiveness will increase. Over much of its history, law's brain science has been the result of trial and error and of a useful but limited folk psychology (Morse 2004a, 2008). The potential impact of making the brain connection explicit and sophisticated is substantial. Law and cognitive neuroscience are natural partners.

Neuroscience Emerges as an Important Field

Cognitive neuroscience itself is now a fully established field of study. In the 1990s, new techniques such as functional magnetic resonance imaging (fMRI) scanning and new models of thought opened up the black box of cognition, marrying the insights of traditional psychology with a functional analysis of the biology of brain activity. Indeed, the term "cognitive neuroscience" was coined during the 1990s to describe this combination.

These new models stand in contrast to the traditional Cartesian view of a unified intelligence. Descartes postulated a unitary center of thought, largely separated from the brain itself, that communicated with the brain via the pituitary gland (Damasio 1994). A similar conception is widespread in naive psychology, sometimes expressed in the idea of the homunculus—a little human in the center of all our thought and will, ordering the mind and body about like the captain of a ship. The captain may not always be heard by the unruly crew, but our naive psychology presumes that the captain is there nonetheless.

Indeed, a somewhat primitive exculpatory argument that "my brain made me do it," rightly condemned by Morse (2006b), depends on a kind of cartoon notion of neuroscience: the well-intentioned homunculus-captain once again overruled, this time by a crew that is manifest in the recalcitrant mechanisms of the brain. Good neuroscience should have no time for such an argument; the processes that create what we inadequately describe as captain and crew are all products of brain function, and a theory of decision making, action, and responsibility grounded in neuroscience must take them all into account.

In the new models, thought is seen as the outcome of a distributed, organic process within the brain. A key step of cognitive neuroscience is the expectation that the approach taken by the individual's mind to solve a problem will be physically present in the workings of her brain. By investigating this physical presence, we can in turn gain insights into the types of solutions available to humans and the cues that switch us into a particular approach. These insights will sometimes confirm the folk psychology embodied in our laws. At other times, they will challenge our traditional beliefs about mental processes, with the possibility of stimulating fundamental changes in how law is framed and applied.

Those who wish to pursue the topic beyond this brief summary have a flood of resources at their disposal. These range from popular works such as Aamodt & Wang (2008) and Carter (1998) to short scholarly treatments such as Goodenough & Prehn (2004), Zak (2004), and Jones et al. (2009), and on to more challenging graduate-level compendiums such as Frackowiak et al. (2004). Undergraduate texts such as Gazzaniga et al. (2008) and Baars & Gage (2007) can serve as useful entry-level guides. The Web site of the Law and Neuroscience Project at **http://www.lawneuro.org** is a good starting point for those looking further. It includes a thorough bibliography of neurolaw publications. Also, at the scholarly level, the Interdisciplinary Research Center for Neurosciences of the Johannes Gutenberg University of Mainz has compiled an extensive bibliography of neuroethics (**http://www.neuroethik.ifzn.uni-mainz.de**) that includes many sources relating to neuroscience and law.[1]

Neuroscience Insights Spread to Other Fields

In the past decade, the new approaches have spread beyond neuroscience and psychology into other fields where mental models matter. Disciplines as diverse as philosophy (e.g., Casebeer 2003, Prinz 2005, Sinnott-Armstrong 2008), economics (e.g., Glimcher 2003; Zak 2004; Fehr et al. 2005; McCabe et al. 2005a,b), and even literary theory (e.g., Turner 1996, Holland 2000, Nalbantian 2003) and art history (Zeki 1999) began to tap the advances of neuroscience. The emergence of academic neuroethics, partly as an offshoot of bioethics, can be seen as part of this stage (e.g., Roskies 2002; Farah 2004, 2007; Glannon 2007a,b; see generally the Web site of the Neuroethics Society, **http://www.neuroethicssociety.org**).

And we are now entering a third phase in the cognitive revolution, a phase in which its insights are moving beyond academia and into application, influencing outcomes in both the private and public spheres. Because law is the interface where public policy meets individual behavior, law and neuroscience should be a central work space and clearinghouse for building and disseminating these developments. If we do the job right, embedding neuroscientific understandings in our legal institutions will allow us to use the new knowledge to better society. And the collaboration between law and neuroscience is not just a one-way street. Law's preoccupation with usefulness can help to direct scientific research toward finding solutions to society's challenges. The law is not, however, always the easiest of partners. Its inherent preoccupation with process, along with other idiosyncrasies of method and result, can surprise and sometimes frustrate those coming to this law-and-neuroscience interaction from a background of science, medicine, ethics, economics, or other fields.

This review first describes the history of the emergence and development of law and neuroscience as a field. Second, it examines some cautions that we need to keep in mind as we approach the application of neuroscience to legal concerns. We then provide a survey of current scholarship in the field, with particular attention to work around courtroom practice and issues of criminal law. Fourth and finally, we discuss how the field might better address challenges that continue to limit the influence and growth of cognitive neuroscience in legal academia and in the world of government and public policy.

DEVELOPMENT OF NEUROLAW

Although there is a long history of interaction between law and psychology (e.g., Frank 1930, Horowitz & Willging 1984, Gruter 1991, Foley 1993; for a brief summary, see Kapardis 2003, Goodenough 2006), the blending of law and cognitive neuroscience began in earnest in the late 1990s. The combination was first put on the table in exploratory presentations and meetings that brought scholars from the two fields together in dialog (Frolik 1998, Wermke & Goodenough 2001, Taha & Nagel 2001, Lempinen 2004, Garland 2004, Hyman 2007b). These conversations led to an increasing flow of articles, books, and dedicated journal

[1]A bibliography aimed at law and the biological sciences more generally is available at **http://www.sealsite.org**. There is a useful, if somewhat unsystematic, bibliography as of May 2007 on "Moral Minds and Empirical Ethics" by Cores Tomsons available online at **http://thoughtcapital.wordpress.com/bibliography-moral-minds-and-empirical-ethics**. The Law and Neuroscience Project plans to develop a scholarly bibliography, a handbook, and other useful resources.

issues (e.g., Goodenough 2001, Garland 2004, Morse 2004a, Zeki & Goodenough 2004). The law and neuroscience interaction received early encouragement from the Dana Foundation (**http://www.dana.org**) and the Gruter Institute for Law and Behavioral Research (**http://www.gruterinstitute.org**), and, beginning in 1999, it increasingly became a focus for presentations at the Society for Evolutionary Analysis in Law (**http://www.sealsite.org**).

Neuroethics, itself an emerging field during this period (see, e.g., Illes 2006, Farah 2007, Glannon 2007a,b, Greely 2007c), also helped to spark thinking about law and the brain. Early on, researchers at the intersection of ethics and the cognitive sciences recognized that their work would have implications for law and public policy and invited legal scholars to join in their deliberations. In 2007, neurolaw received a boost forward with the launch of Phase I of the Law and Neuroscience Project, funded by a $10 million grant from the MacArthur Foundation and led by its director, Michael Gazzaniga, and codirectors, Walter Sinnott-Armstrong and Stephen Morse (**http://www.lawandneuroscienceprogram.org**). As of mid-2010, Phase 1 was winding up its activities, and Owen Jones had undertaken the directorship of the next phase.

The MacArthur Education and Outreach Program, working through the Gruter Institute, and the Dana Foundation, in collaboration with the American Association for the Advancement of Science, have mounted workshops for judges at the state and federal levels (see **http://lawneuro.org/outreach.aspx** and **http://www.ncsconline.org/D_Research/stl/dec06/Judicial%20Seminars%20Biographies.doc**). Both have worked with the National Judicial College (NJC; **http://www.judges.org**) and the Federal Judicial Center (FJC; **http://www.fjc.gov**), the nation's leading centers for nonpartisan judicial education. Individual states also increasingly include presentations on law and the brain in their regularly scheduled judicial training sessions.

Universities and law schools have recognized that law and neuroscience is an important field, listing courses, hosting conferences, convening symposia, and even launching dedicated initiatives and centers, such as Baylor's Initiative on Neuroscience and the Law (**http://www.neulaw.org**) and the University of Pennsylvania's Center for Neuroscience and Society (**http://neuroethics.upenn.edu**). There are active academic bloggers on the subject, most notably the excellent Neuroethics & Law Blog, hosted by Adam Kolber (**http://kolber.typepad.com**), and the blog of the Law and Neuroscience Project (**http://lawneuro.typepad.com/the-law-and-neuroscience-blog**). The publication by ABA Publications in 2009 of the brief self-help volume by David Sousa entitled *How Brain Science Can Make You a Better Lawyer* marks a milestone of sorts as well (Sousa 2009).

The mainstream media has woken up to law and neuroscience. "Brain Scans Go Legal" appeared in *Scientific American Mind* in December 2006 (Grafton et al. 2006), and a long article by Jeffrey Rosen entitled "The Brain on the Stand" in the March 11, 2007, *New York Times Sunday Magazine* (Rosen 2007) marked the official arrival of the subject in the popular consciousness. Since then, articles have appeared across the media landscape, largely reporting on developments in fMRI lie detection or mind reading (T. Frank 2008—*USA Today*, Barrie 2008—Fox News, Callaway 2009—*New Scientist*, Leggett 2009—*Wired*, Miller 2009—*ScienceInsider*, Narayan 2009—*Time*), but also investigating the use of neuro-enhancing drugs (Talbot 2009—*New Yorker*), exploring the roots of psychopathy (Seabrook 2008), and questioning the seat of consciousness in the brain (Tallis 2010). In the summer of 2010, National Public Radio ran a three-part series on neuroscience and responsibility on *Morning Edition* (NPR 2010a,b,c) and devoted much of a *Talk of the Nation* broadcast to the subject as well (NPR 2010d).

Internationally, London is a center for brain research, and it has been a center for neurolaw activity as well. British presses and journals have published books and special issues on the subject (e.g., Freeman 2006, Zeki & Goodenough 2006, Freeman & Goodenough 2009). On the Continent, the Berlin Neuroimaging Center has undertaken research and hosted conferences on neurolaw issues (Wermke & Goodenough 2001). In December 2008, the courts of Milan, Italy, organized a conference on law and neuroscience (Santosuosso 2009), and Italy is a center for growing attention to this field. As is described more fully below, India has jumped—perhaps precipitously—to the forefront in introducing neuroscientific testing as evidence of guilt in a criminal trial. Back in the United States, neuroscience findings have made their way into explicit Supreme Court jurisprudence, with a citation to brain development in the 2010 decision in *Graham v. Florida*. As the foregoing illustrates, neurolaw has established solid roots and raised considerable societal interest.

CAUTIONS AND CONCERNS

The new models of thought arising out of cognitive neuroscience can help us find answers to questions in law that have proven hard for traditional psychology and the other social sciences to resolve. There are, however, real dangers to making poor use of science of all kinds in formulating policy and legal rules, and there are dangers that are particular to biologically grounded approaches. Our conclusion, however, is that the neuroscience genie is out of the bottle. The job of good scholars working in this field is to remember the potential for these mistakes and to keep ourselves open to both internal and external critiques as we seek to avoid making them.

Caution #1: Avoid Using Neurodazzle to Justify Conclusions Arrived at for Other Reasons

When science has been invoked to justify social policy, it has all too often served as a post hoc justification for conclusions arrived at for other reasons. Such practices have ranged from the ridiculous to the horrendous. The hallmarks of this inappropriate bolstering appear in three scenarios outlined in the context of environmental law and science (Ruhl 2007). In one scenario, policy makers are at fault, as they either interpret the science only so far as it supports their policy agenda or negligently ignore it altogether, citing overriding policy concerns. In the second scenario, the scientists and meta-analysts are at fault, presenting the science in a way that unfairly dictates their policy agenda and preferred outcome. Finally, in what Ruhl calls "the ultimate law-science conspiracy," the policy makers and scientists together design the science inquiry to lead inevitably to their mutually chosen policy agenda outcome.

The tendency for post hoc justification is enhanced in law, where the drive, at least in the litigation context, is toward a definitive yes/no answer. The legal process is designed to reduce complexity and ambiguity so that such an answer can be obtained and uncertainty abandoned, at least for the case at hand (Victoroff 2009). Science, by contrast, is characterized by its persistent investigation, even in the face of settled questions. The potential of neuroscience to give fresh insights into problems that have long vexed the law will only come to fruition if those insights, and not preconceptions, drive the analysis and neurolaw scholars let the chips fall where they may.

Caution #2: Neurolaw Is Not Simple Determinism: Many Factors Shape a Human Being

Scientifically speaking, of course, cognition is all biology. But this should not be taken as a declaration of some kind of simplistic "Biological Determinism." The influences on that biology are multiple and complicated (Jones et al. 2009). For instance, the genetic inheritance of all humans, and of the particular human in question, is an important, but not conclusive, factor. Humans start with genetic programs that produce human brains, not chimp brains or cat brains. There is a great deal of commonality across the human genetic code ranging from language ability, color perception, a sense of self, and a capacity for understanding the agency of others—the so-called "theory of mind" (Baron-Cohen et al. 1993, Coricelli et al. 2000). Then again, some individuals have differences or even deficits in their capacities for particular functions—indeed all of us, if compared to some kind of average human, have lapses and gaps.

The genetic program, however, is just that—a program, and not a finished result. The process of building the finished result depends more or less continuously on input from the ambient environment, input that can profoundly shape the eventual outcome of growth and development. In scientific terms, this interaction is often called "epigenesis" (Glannon 2009, Kaplan 2009). Or, as the old saying expresses it, "as the twig is bent, so the tree will grow" (Pope 1712 [1966]). Humans are a remarkable composite of influences. The physical environment matters. The social environment matters. Culture matters. Personal experience matters. All of these, however, if they are to have a lasting effect on thought and behavior, must either interact concurrently with the brain or must have left some mark on the brain as it developed. Finally, the human brain has the ability to shape itself, through processes such as rational planning and self-reflection. But again, we believe this is also an essentially physical process, expressing itself in the biology of the brain. And, the philosophic cautions of writers such as Pardo & Patterson (2010) notwithstanding, we believe that by investigating the physical processes that support thought and action, we can get new and useful insights into how thought and action arise.

Caution #3: Creating a Stigmatized Other

There is a particular challenge in facing up appropriately to the differences that may exist in the mental architectures and capacities of individuals. The law is at least in part about assessing people who have deviated from some communal expectation. As is discussed in the survey of research, unpacking the role that the various factors in the experience/architecture composite have played in creating socially unacceptable outcomes of thought and behavior can help us to make better choices about our interventions. For instance, the work of Kent Kiehl on psychopathy (e.g., Kiehl et al. 2004, 2006; Kiehl 2008), discussed below, holds tremendous promise for diagnosis and prediction among a class of people who are already diagnosable with reasonable reliability using traditional psychological screening and who are disproportionately represented in our incarcerated population.

Finding difference, however, can also lead to stigmatization and a distancing from "the other." The law has a poor history of using such socially constructed differences as race, gender, and ethnicity as markers for discrimination and even persecution (e.g., Greely 2007a, Fine 2008, Rothenberg & Wang 2009). In the context of mental illness, Pustilnik (2006) reminds us how humans create categories for other people that can set them apart and allow us to treat them in ways that are ultimately cruel and dehumanizing. Giving such a process a scientific gloss is all too common in history. If we start looking for the criminal mind, whether using phrenology or the best of the new neuroscience, we are all prone to forget that an inner criminal lurks in most of us, waiting for the right cues of anger or desperation to emerge (e.g., Goodenough 2004; see generally Farahany 2009b). Furthermore, we may be tempted to forget that what is defined as criminal has varied over the course of our history, so that what was criminal in the past is no longer and vice versa. Thus, it is not possible to infer brain dysfunction merely from unlawful behavior (Pustilnik 2006).

REVIEW OF CURRENT RESEARCH

In its decade of existence, neurolaw is already broad enough that a review of this scope cannot begin to be an encyclopedic compendium of all that is going forward. We direct scholars looking for further resources to the helpful survey treatments by Tovino (2007), Greely (2007b, 2009), and Belcher & Sinnott-Armstrong (2010); to the recent books edited by Farahany (2009b), Sinnott-Armstrong (2008), and Freeman & Goodenough (2009); and to the references in this review generally.

Where Is Neuroscience Likely To Be Additive?

As the review set out below suggests, neurolaw enthusiasts are finding its approaches useful in a wide range of contexts. That does not mean that its utility is universal. The selection of questions for study is an important first step. For some questions of interest to the law, the folk psychology of law itself or traditional behavioral psychology may have already provided good solutions (Morse 2004a, 2008). Law and neuroscience research can most profitably aim at problems where accepted doctrine fails to achieve results and where existing legal scholarship cannot answer for these failures. For instance, Goodenough & Decker (2009) point to intellectual property, and particularly copyright, as such an area. As discussed below, neurolaw scholars are identifying a wide range of other targets.

Major Divisions in the Field

Viewed from a law researcher's perspective, the field may be divided into three streams of investigation. First, there is the law that is applied to neuroscience. This includes the rules governing the basic research and experimentation at the heart of the cognitive revolution. It also includes the regulation of treatments and interventions both to cure disease and, increasingly, to provide enhancements for the basically healthy. Various aspects of intellectual property, privacy, finance, and other disciplines related to innovative and entrepreneurial science also fall into this category.

A second category, with the widest scope for investigation, involves the study of cognition and behavior relevant to the law in its daily application and also to the policies and societal goals that law seeks to promote and further. This area includes applications in the courtroom, such as truth and memory assessment. It also includes a better understanding of the range of behaviors, favored and disfavored, that the law seeks to control and promote, often in the criminal context. Thus, neurolaw is investigating such challenges as drug addiction, psychopathy, impulsive violence, sexual abuse, and financial predation. On a more positive side, we are also gaining insight into trustworthiness, promise keeping, respect for property, and self-control (O'Hara 2008).

Third, researchers are exploring the cognition and behavior of law itself, as it is created, enforced, and applied. Legal processes encompass, supplement, and control other modes of normative judgment (Goodenough & Prehn 2004). Studies of moral reasoning, legal reasoning, and economic decision making, for instance, are shedding light on how we view the severity of crimes (Buckholtz et al. 2008, Cushman 2008), the factors that lead to decisions of culpability (Cushman et al. 2006), and the utility and basis of punishment (Seymour et al. 2007, Dreber et al. 2008).

Law of Neuroscience

Our first category—the law of neuroscience—involves the study of the law and policy that should govern the activities of neuroscience, including research and applications.

Regulating neuroscientific research. One obvious and overarching hurdle for any neuroscience research on human subjects is the matter of voluntary and informed participation (Greely 2008, Tovino 2008; see generally Manson & O'Neill 2007). This concern is heightened when the potential targets of a study include a vulnerable population. Traditionally, this category has included children, the elderly, and people with disabilities. Some suggest that this category should also include people whose behavior has put them in conflict with the law. Prisoners, psychopaths, addicts, and people experiencing psychosis are also vulnerable for consent purposes and may require special protocols for testing because of an impaired capacity to consent (Hall et al. 2004, Greely & Iles 2007). Research on these and all populations presents the ethical dilemma of gaining voluntary participation while also gathering data from a sample of meaningful size, character, and diversity (Greely & Iles 2007, Judd et al. 2009).

Privacy concerns are widespread in research, diagnostic, and treatment contexts (e.g., Greely 2004). The challenges are even more intense when the target of study is the internal thoughts and feelings of the subjects (Canli & Amin 2002, New York City Bar 2005) or when the goal involves mind control for therapeutic or incapacitation purposes (Levy 2007, Greely 2009). When this knowledge is used in a criminal context, there are further challenges concerning the application of the constitutional guarantees of the Fourth and Fifth Amendments (Finn 2006, Pardo 2006, Tovino 2007). Use of brain-scanning technologies may constitute a search for Fourth Amendment purposes, which may require a warrant or, in its absence, probable cause (Pardo 2006).

Consciousness and brain death. Recent brain-scanning experiments have reignited the debates over consciousness, vegetative states, brain death, and the rights of coma patients. Functional neuroimaging has proven useful for probing volition and residual cognition of patients who have no capacity for motor output and who may thus be mistakenly diagnosed as vegetative. A series of experiments and papers by Monti et al. (2009, 2010) has built on the idea that the performance of discrete mental tasks separately identifiable in the scanner may be a way to enable otherwise noncommunicative patients "to use their residual cognitive capabilities to communicate their thoughts to those around them by modulating their own neural activity" (Monti et al. 2009). The repercussions of this for the law are not yet established, but enhanced therapeutic treatment might be required under the Americans with Disabilities Act for patients in this category who show evidence of consciousness.

Enhancements. Neuro-enhancements may be used to modify memory, wakefulness, attention, and sensory perception. Although the enhancement of physical performance in sports has garnered attention and legal response (e.g., Coleman & Coleman 2008, Recht 2008, Sigman 2008), the enhancement of mental performance has only begun to be considered in ethics and law (Farah et al. 2004; Greely 2005a,c, 2009; Hyman 2006). Most of the attention to date has been on neuro-enhancing drugs (Greely et al. 2008), but sensory prosthetics are in development as well (Greely et al. 2007, Greely 2009). Military applications to create more effective combatants are being developed (Canli et al. 2007). The line between treatment, enhancement, and cheating can be blurry (Levy 2007). Guidelines for the protection of human subjects that were developed for investigations of therapeutic treatments are not an adequate basis for considering how to approach enhancement (Mehlman & Berg 2008). Klaming & Vedder (2009), citing the fact that eyewitness memory has been shown to be unreliable, have suggested using neuro-enhancements to improve witness memory. Exploring a different side of the memory issue, Kolber (2006) has considered the potential use of interventions for memory dampening (a kind of negative enhancement) for voluntary and involuntary therapeutic purposes. Concerns over memory enhancement in the courtroom are discussed below.

Intellectual property. Intellectual property is another branch of law with application to neuroscience. Although questions around the patents of neuroscience technology are interesting, they can be largely captured within existing principles. Some have envisioned the more challenging possibility of patenting mental processes as an issue that the law will be called upon to resolve (Greely 2004, Tovino 2007). The inclusion of mental processes looks unlikely at this point, however. The recent decision by the U.S. Supreme Court in *Bilski v. Kappos* (2010), affirming the appellate court's decision in *In re Bilski* (2008), limited process patents in the business context and may point to a more restrictive environment for nontraditional process patents more generally.

Neuroscience of Thought and Behavior of Interest to Law

This area—the intersection of neuroscience and law in its daily application to human behavior and thinking—encompasses the widest range of neurolaw investigation. What is the context within law where matters of thought and behavior arise? For many, law implies a courtroom, and law and neuroscience involves the application of brain science techniques to the challenges of establishing facts at a trial. Therefore, we begin with the use of neuroscience in court, progress to a discussion of applications of neuroscience to legislation and policy, and conclude with neuroscience discoveries about legal decisions and punishment.

Revealing subjective states. For example, there are attempts to use neuroscience to develop objective methods for assessing what have been inherently subjective questions. Truth-telling and lie detection, mental capacity, pain, and memory reliability are useful areas of study for criminal and civil litigation. These attempts at mind reading are becoming theoretically possible. Experiments in controlled conditions allow the inference that a subject is engaged in thinking about a particular object or memory, with accuracy rates well above chance (O'Craven & Kanwisher 2000, Shinkareva et al. 2008, Rissman et al. 2010). But there is reason to be concerned about the application of such techniques in actual fact-gathering circumstances (Wolpe et al. 2005, Greely & Iles 2007, Kolber 2007, Tovino 2007, Seaman 2009, Greely 2009, Vincent 2009a). Reliability is questionable, and important issues of neural privacy are only beginning to be addressed (e.g., Kolber 2007, Tovino 2007).

Truth-telling and lie detection. One application that is already receiving commercial attention is the neuroscience-enhanced lie detector. Determining whether another human is being intentionally deceptive is a prime challenge in many contexts, and the search is on for a reliable technique to assess truth-telling in a suspect, a witness, an informer, or an enemy combatant (Garland & Glimcher 2006, Tovino 2007, Merikangas 2008, Langleben 2008, Sinnott-Armstrong 2009, Aronson 2010, Brown & Murphy 2010, Kolber 2010). While there are some promising starts in the research (Abe 2009, Greene & Paxton 2009), the desire of lawyers and governments to use neurotools is getting ahead of reliability (e.g., Moreno 2006, Aronson 2010).

Some techniques championed by companies such as No Lie MRI (**http://noliemri.com**) and Cephos (**http://www.cephoscorp.com**) use fMRI brain imaging as their basis for assessing truthfulness. As with any brain imaging study, however, detecting lying depends on identifying some measurable activation pattern that can be linked to the targeted behavior, in this case reporting untruths (Langleben 2008). For instance, an approach might target patterns of concentration and creativity linked to making up an untrue story. Lying is often harder mental work than simply recalling and reporting the contents of memory, although even truthful recall can engage selectivity and creativity (Pardo 2006). Unfortunately, the added effort of confabulation would likely dwindle or even disappear on subsequent tellings of the lie—where the task would revert to memory.

Other targets linked to lying could be those associated with tension or inner conflict. Unfortunately, these regions are likely to be activated in circumstances in which we encounter difficult problems or social situations and we need to control our responses (Spence et al. 2001), circumstances that might plausibly include answering police questions while immobilized in a claustrophobic, noisy scanner. Furthermore, as discussed above, most scientific research to establish activation targets uses averaging over a pool of subjects. Transferring such data to the analysis of activation in a particular individual will always be problematic. And establishing comparative regions in a single, often recalcitrant, subject

***Daubert* test:** the test for the admission of scientific evidence announced by the U.S. Supreme Court in the case *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (509 U.S. 579 (1993)

in a criminal context will be a particularly challenging undertaking. Most of the actual cases to date have involved results offered into evidence on behalf of the person tested.

Researchers have proposed other truth-assessing techniques. Some rely on identifying a signature for seeing known locations or hearing known facts as opposed to locations or facts that are novel. These techniques may use external measurements—such as electroencephalography—to detect excitability in the brain during recognition exercises (Pardo 2006, Mobbs et al. 2007, Aronson 2010). A variation of this technique called BEOS (brain electrical oscillations signature) was admitted at trial in India in 2008. It was alleged that a young business student and her new husband had killed her former fiancé. She was questioned about the events while undergoing the BEOS measurement, which purportedly suggested knowledge consistent with having committed murder. The judge convicted the defendant, relying in part on the results of the BEOS test (Giridharadas 2008, Moreno 2009). The use of the technique caused considerable controversy, and an expert scientific committee has recommended its discontinuance (Aronson 2010).

In the United States, this kind of technology has not been employed widely at trial (Aronson 2010, Myers 2010), but at least one court has admitted evidence of this kind offered for the defense in a postconviction proceeding (*Harrington v. State of Iowa* 2003). Such an approach raises concerns, both on the grounds of general scientific validity of the supposed brain fingerprint and on the grounds that prior exposure to the suggested story of guilty knowledge during interrogation may contaminate the cognition, making the counterfactual suggestion as familiar as the true events themselves.

So where does this field stand? Most academic commentators have been at best skeptical, with Greely explicitly calling for regulation (Greely 2005b, Garland & Glimcher 2006, Greely & Illes 2007, Aronson 2010, Kolber 2010). Wolpe et al. (2005) note that the vulnerability to countermeasures of the various mind reading techniques is unknown. The counterargument for admitting these techniques is that this type of brain imaging, while not perfect (Kozel et al. 2005), appears more reliable than the current polygraph test (Mobbs et al. 2007), and it may offer an opportunity for an innocent defendant to corroborate her version of events. Schauer (2010) argues that even scientifically flawed techniques may someday provide legally useful evidence. Pardo (2006) anticipates that effective and admissible neuroscientific methods of lie detection may be developed and explores the constitutional issues that such tests will raise.

In a pair of recent cases, judges have ruled against attempts to introduce evidence drawn from scanning-based truth detection techniques. In a state court case in Brooklyn, New York, the plaintiff had sought to introduce evidence of her truthfulness derived from a Cephos-conducted test (Madrigal 2010b). In excluding the evidence, the judge noted the concerns raised about the scientific validity of such testing but cited the traditional allocation of credibility assessment to the jury as the reason for the decision (*Wilson v. Corestaff Services* 2010).

A federal court in Tennessee was equally unwilling to allow a Cephos test into evidence, in this case by a defendant seeking to avoid conviction on charges of defrauding the government (Madrigal 2010a). In a detailed report and recommendation applying the Federal Rules of Evidence discussed more fully below, the magistrate judge concluded that the evidence would not satisfy the *Daubert* test necessary to meet the requirements of Rule 702. Furthermore, making a comparison to the excluded polygraph technique, he concluded that the evidence could be excluded under Rule 703 as potentially prejudicial (*United States v. Semrau* 2010).

Pain. Pain is significant to the law in many contexts, including injury-related pain in tort and labor law (Kolber 2007, Tovino 2007, Pustilnik 2009). Where pain is reported, neuroscientists have been able to view activity in the brain corresponding to a pain response.

However, without verification by voluntary responses of a subject, researchers have yet to demonstrate any particular pattern of brain activity that reliably indicates the presence of pain (Miller 2009). Kolber (2009a,b) has also raised the question of the subjective nature of pain as part of punishment and has suggested that we may want to modulate criminal penalties to reflect the amount of distress they are actually causing to a convicted offender.

Memory. The reliability of memory is of great interest to court proceedings. Neurological and behavioral studies bring our assumptions about accuracy into question (Schacter & Slotnick 2004). Phelps & Sharot (2008) have shown that subjects' memory confidence is directly proportional to the emotional content or effect of the experience remembered, but such confidence has only limited correlation to actual accuracy. Studies that show the limits of our awareness of external stimuli have implications for victim and eyewitness testimony (Ortinski & Meador 2004, Schacter et al. 2008). On the enhancement side, there is potential for pharmacological interventions that can enhance memory (Klaming & Vedder 2009) and that can help suppress it in painful circumstances (Kolber 2006). The law has struggled with the problem of false or implanted memory—untrue, but honestly held by a witness. Developing means to distinguish such memories, both from truly witnessed facts and from intentional deception, would be a worthy target for the future of neurolaw.

Evidence. Getting neuroscientific results into the courtroom in a specific case raises several issues for the law of evidence. The science itself must meet tests of reliability and acceptance, and its application to the legally relevant question must also be established (e.g., Greely 2004; Garland & Glimcher 2006; Feigenson 2006, 2009; see generally Faigman et al. 2009). Aronson (see Aronson 2010 in this volume) provides an in-depth discussion of the science and policy behind the use of neuroscience evidence in the courtroom and in a variety of other legal contexts.

Scientific validity. In federal courts and in a majority of the states, the law of admissibility for scientific evidence is grounded in *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (1993). In this case, the Supreme Court set out criteria for applying Federal Rule of Evidence 702 on scientific expert testimony. These include (*a*) the ability to reliably replicate the scientific results in repeated tests, (*b*) validation of the methods by peer review and publication, (*c*) the error rate incorporated into test results, and (*d*) general acceptance within the relevant field. These factors are supposedly applied without weighting one over another, but Moreno (2009) argues that judges do not reach the arithmetical concerns of replication and error rates relative to burden of proof unless the science is also either generally accepted in the relevant field or has been well received and validated in a peer-reviewed setting.

The most widespread alternative to the *Daubert* test is the *Frye* standard (e.g., Feigenson 2009). This test dates back to 1923 and was enunciated in a case reviewing the admissibility of the polygraph form of lie detector (it was ruled inadmissible) (*Frye v. United States* 1923). *Frye* has been seen to require general acceptance of the science on which the testimony is based, a standard generally viewed as more restrictive than *Daubert*, particularly with respect to emerging science. The differences between this and *Daubert* can be overstated—whatever the announced test, courts look to the acceptance of the science in the scientific community and to its replicability.

A recent challenge to the reliability of some scanning science has come from within the academy. Vul & Kanwisher (2010) discuss what they term the "nonindependence error" in fMRI research. To simplify, the means used to target areas of interest can bias the later results toward significance. Vul et al. (2009) first argued that cognitive neuroscience research is particularly vulnerable to this kind of error because of the amount of multidimensional raw data emerging from each study, the complex and multilevel processing needed to transform that raw data into understandable results, and

***Frye* standard:** the older test for the admission of scientific evidence announced in the case *Frye v. United States*, 293 F.2d 1013 (D.C. Cir., 1923) the potential hazard of evaluating binary outcomes as significant in a qualitative investigation. Vul & Kanwisher (2010), following the uproar over Vul's earlier work, offer methods to identify this error in experimentation and to prevent the error in design.

Relevance. Of greatest importance to admissibility in court is the question, "What is the relevance?" Even when the science on offer is deemed reliable enough to pass muster, the relevance prong of the admissibility test (Rules 401 and 402 in the federal system) requires that it be probative of some fact at issue in the case. This requirement can be a problem for some kinds of neuroscience evidence. For instance, a scan may reliably show the existence of a tumor in a defendant trying to claim diminished responsibility, but the meaning of that tumor with respect to behavior may be open to question—does it have anything reliable to say about the actual issue in the case (e.g., Burns & Swerdlow 2003, Batts 2009, Farahany & Coleman 2009, Jones et al. 2009, *People v. Weinstein* 1992)? In their useful guide on *Brain Imaging for Legal Thinkers*, Jones et al. (2009) suggest two questions that will help focus the relevance analysis and that should be answered even before determining whether the scientific reliability of the evidence will meet the necessary standard:

- What specific legal questions do the images purportedly address?
- What, specifically, do the images allegedly demonstrate, and how well does that connect to the legal issues at hand?

Even the best neuroscientific studies are often based on data gathered across many subjects, and they may not be probative when offered as proof about the characteristics of a particular subject in the case at hand (Feigenson 2009, Hughes 2010).

Prejudice. In addition, even probative evidence can sometimes be kept out if it is likely to be prejudicial. Federal Rule 403 states:

> Although relevant, evidence may be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury, or by considerations of undue delay, waste of time, or needless presentation of cumulative evidence.

There are serious concerns that neuroscience—particularly when accompanied by pretty pictures of brain scans—leads to excessive deference and credibility (Dumit 2004, Feigenson 2009; see also Aronson 2010). This is sometimes called the "Christmas tree phenomenon" (Mobbs et al. 2007, Feigenson 2009). Scientific evidence in general can sometimes be overly persuasive, even when presented by a careful expert in a responsible manner (Boudreau 2009). Many believe that the cachet of science is even more pronounced when it comes to the study of the brain. Support for this effect was given by Weisberg et al. (2008), who showed that adding neuroscientific explanations to otherwise commonplace behavioral observations made them seem more authoritative. The authors recognized, however, that the study may not differentiate between a neuroscience-specific effect and the effect, already known, of adding any type of complex scientific explanation to testimony or evidence. Other studies have also shown that people are too easily persuaded by arguments—even faulty ones—that include brain-scanning images (McCabe & Castel 2008), although very recent, as yet unpublished, work appears to call this effect into question.

But a potential for prejudice does not make neuroscience evidence inadmissible per se. That would be the case only if the potential for prejudice substantially outweighs the probative value. If the process adheres to the evidence rules and case law and the litigants take the time to educate the jurors, Feigenson (2009) argues that the overall result is likely to be that jurors' biases and misunderstandings are better held in check by more information rather than less. "The cure for naive realism is more, not fewer, images," he declares (see also Compton

2010). Brown & Murphy (2010), by contrast, argue against admission, at least as evidence of past mental states. In the recent instance of the death penalty determination of self-proclaimed psychopath Brian Dugan, the judge split the difference, allowing scanning-based testimony to go forward but prohibiting the showing of the individual scans themselves (Hughes 2010). As discussed above, the court in *United States v. Semrau* excluded scanning evidence offered to corroborate credibility under Rule 703 on the grounds of potential prejudice.

Results for the courtroom. So, how is neuroscience evidence likely to fare? As noted above, Feigenson (2009) gives admissibility guarded approval. Moreno (2009) has argued that the admissibility of neuroscience evidence is unlikely, although more because of problems of relevance to the issues at stake in the case than because the underlying neuroscience was poorly executed as a matter of academic research. Farahany & Coleman (2006) report that courts have frequently rejected attempts to get this kind of evidence admitted, often on the grounds that the science is not fully in place, a sentiment shared by Greely (2008). Brown & Murphy (2010) suggest that neuroscience evidence is most likely to be admitted when it is linked with behavioral indications and correlated with psychological measures, forming a complete picture in which the neuroscience is just a part. The recent holdings, discussed above, excluding scanning evidence offered to confirm credibility, demonstrate that admissibility is likely to be an uphill battle.

Criminal law. Much of the neurolaw activity has been in fields that relate to criminal law. In part, this reflects the understanding—widespread among those working in the U.S. criminal system—that the system we have now and the solutions we have adopted are not working as well as anyone would like. The United States is renowned as the incarceration leader of the world (Liptak 2008), and this policy is widely criticized for being expensive in monetary and human terms.

Many critics—along with a surprising number of judges and other people involved in the system—are eager to find better approaches for dealing with the mental health, drug, and youth offender problems that are implicated in such a large part of the criminal dockets in state and federal courts. They are also eager to find new diagnostic and prediction tools that can enable society to do a better job distinguishing between those for whom some treatment model may work and those for whom incarceration is the best option after all. Reform has made few inroads, however, even in setting minimum standards for executing mentally incompetent offenders (Perlin 2010, *Panetti v. Quarterman* 2007). Thinking back to the discussion of good targets for neurolaw research, these are areas where the current approaches and explanations are not doing the job and where the advances of neuroscience have promise for helping us find better solutions.

Substantive areas of law and policy. As a starting point, neuroscience can help us establish the underlying policies and fix the boundaries around certain kinds of behaviors that we might choose to penalize. For example, there is considerable debate currently about distracted driving, and particularly the role of cell phones, texting, and other digital technologies, in causing accidents. Several states have implemented or are considering bans on text messaging while driving, and a majority include distracted driving in their state highway safety plans (Gov. State Highw. Assoc. 2010). Neuroscience studies such as Young et al. (2005) that present real-time functional imaging of distracted brains can help clarify the cognitive problems posed by such multitasking.

Cognitive and behavioral knowledge of this kind could be helpful in various criminal law contexts. We need better feedback between policy, law, and good empirical data. A concern, however, arises when the issue becomes political, and the kind of recrimination and science-for-hire problems that have beset topics such as tobacco use and global warming come to the fore. The problems that such controversies can pose—particularly for research scientists—are addressed in the final section of this review.

Responsibility. Questions about responsibility and free will have attracted academic attention—perhaps too much (Hodgson 2000; Greene & Cohen 2004; Sapolsky 2004; Goodenough 2004; Eastman & Campbell 2006; Farahany & Coleman 2006; Roskies 2006; Morse 2004a,b, 2006b,c, 2007, 2009; Aharoni et al. 2008; Batts 2009; Claydon 2009; Greely 2008, 2009; Blumoff 2010). In the law, responsibility is a question that arises in the guilt or innocence phase of a U.S. criminal trial, typically through some claim of a lack of capacity, such as the insanity defense (see generally Goodenough 2004, Tadros 2005). As neuroscience provides better models of the pathways that lead from sensory input through thought and on to action, these models can challenge some of our assumptions about free will, and with them a perceived premise of our punishment-based system (Greene & Cohen 2004, Sapolsky 2004).

At one extreme, some accused of criminal acts may try to assert a cartoon neuroscience, claiming "my brain made me do it," as if the brain were somehow a separate matter from the internal captain of the old homunculus model, discussed above (Tallis 2007). In justifying such an argument, the accused might point to the experiments of Libet (2000) that suggest that some decisions are made in the brain before any reportable consciousness of the decision arises. At a more sophisticated level, some authors have argued that a better understanding of the mechanisms of inhibition and control will necessarily change how we view those persons in whom those mechanisms have failed (e.g., Greene & Cohen 2004, Sapolsky 2004).

On the other side, some scholars have criticized a neuroscience-based attack on responsibility. With respect to Libet's findings, there is no reason to believe that the delayed timing of the report by consciousness reflects a failure of the underlying processes of consideration, desire, and inhibition to have taken place in a way that might resemble deliberation and choice (see generally Nadel & Sinnott-Armstrong 2010). The survey of cases by Farahany & Coleman (2006) suggests a drawback in the whole strategy: A claim of neurological predisposition to criminal activity can be a double-edged sword, as likely to create a desire for additional jail time as to lead to some excuse (also see Snead 2007, Hughes 2010).

This is not really a new debate. Although the neuroscientific findings put the question of determinism into sharp perspective, it has considerable history. In his 1978 book *Freewill and Responsibility*, Kenny (1978) discusses several versions of the determinism argument. Even before the neuroscience revolution, he described a "physiological determinism," "understood as the view that all human activity is determined via neurophysiological states of the brain and central nervous system" (pp. 30–33). Kenny argues that physiological determinism is compatible with a kind of philosophic freedom of will and further concludes that "the issue of determinism is irrelevant to the question of responsibility. The bogey of determinism cannot be used as an argument against the ascription and assessment of responsibility" (p. 34).

In a similar move, Morse (2004a, 2008) has pointed out that there is nothing in the law of responsibility that actually depends on a notion of free will and that the traditional folk-psychological approaches to assigning responsibility seem to fit with our desires for punishment. Drawing on her dual background as a neuroscientist and a philosopher, Roskies (2006) elaborates the arguments for decoupling free will from legal and moral ideas of responsibility. Vincent (2009a,b) breaks the discussion down further, suggesting that the complexity of the concepts of free will and responsibility make any simple conclusions difficult.

Kenny takes a further important step in his treatment of these questions. He declares that "[r]esponsibility, in the appropriate sense, is liability to punishment; and so the justification of responsibility is closely connected with the justification of punishment" (Kenny 1978, p. 69). From this starting point, responsibility can be viewed as a descriptive property of those acts and actors that we choose to punish, rather than as somehow a necessary and independent predicate to punishment. Farahany & Coleman (2006), quoting Halleck (1986), suggest that the law is making a similar choice:

> The presumption [that humans are autonomous actors] derives, in part, from the belief that "social systems are strengthened by holding people responsible for their conduct," and undermined by shifting responsibility to the many factors affecting human behavior such as environmental influences or family upbringing (pp. 136–37).

In a similar vein, Goodenough (2004) draws a rationale for punishment from the strategic needs of game theory. He suggests that there are good reasons in mapping the contours of whom we should punish for the law to proceed as if there were free will on the part of most defendants. Viewed from the perspective of the punisher, punishment is the outcome of a promise linking act and consequence. The keeping of that promise is a necessary part of its effectiveness as a deterrent. The promise can be made partly conditional, and the mental state of the offender can be taken, more or less, into account in creating conditions. But free will does not come into it. By the very nature of the system, those being punished will always be the undeterred, at least if the system is working correctly. This kind of system is by its nature deterministic, in the sense of directly linking cause and effect (Kenny 1978). The limited exceptions that the law is willing to recognize may better reflect the psychology of punishers than of those being punished.

Civil law. Criminal law is not the only context for neurolaw-relevant research. Civil law is another potentially vast area where some neurolaw work has been done but where much more remains to be explored.

In the context of litigation and tort, issues with bearing on claims for civil liability are receiving attention. One such target is the psychology of bias and discrimination, particularly in the context of America's great challenge of racial bias. Several studies (e.g., Hart et al. 2000, Phelps et al. 2000, Phelps & Thomas 2003, Richeson et al. 2003, Cunningham et al. 2004, Wheeler & Fiske 2005, Phelps 2006) have shed light on the processes underlying prejudice and suspicion. Building on tools such as the implicit association test (Lee 2005), this work may hold promise for a mind reading assessment, based on scanning, that can implicate elements of biased reactions, whether based on race, gender, or other suspect classifications (Greely & Iles 2007). Such a test could be useful in such contexts as discrimination litigation (Lee 2005) or jury selection. The underlying research can also lead to insights and strategies to help improve interracial interactions (Richeson & Shelton 2007).

Moving beyond litigation and into the law of transactions, firms, and economic cooperation, neurolaw has another, largely untapped, opportunity. There is a great deal of underlying scientific work on which to draw, much of it coming out of neuroeconomics. Leading researchers include Zak (Zak et al. 2005; Zak 2007, 2008), McCabe (McCabe et al. 2005a,b), Wilson (Kimbrough et al. 2008), Glimcher (2003), Camerer (2003), Delgado (Delgado et al. 2005, 2008), and Fehr (Fehr & Gächter 2002, Fehr & Camerer 2007). Knutson (Knutson et al. 2000, 2001; Kuhnen & Knutson 2005) has investigated entrepreneurship, risk taking, and reward. Some legal scholars have picked up on the work, including Stake, examining the intersection of evolutionary biology and property law (Stake 2004, but see Barros 2010); Goodenough, pursuing the unique challenges of regulating intellectual property (Goodenough & Decker 2009) and the implications for the law of mechanisms of commitment (Goodenough 2009) and fairness (Goodenough 2008); O'Hara & Hill (2007, O'Hara 2008) on contracts and trust; and Benkler on cooperation (Rand et al. 2009). The field is ready for further development.

Neuroscience of the Law Itself

This discussion has moved us from looking at the targets of law to the processes of law and the actors within law—judges, juries, etc. We now address the last of the three categories—the neuroscience of law and normative judgment. While some initial work has pursued the cognitive aspects of legal judgments generally (Schleim et al. 2010, Goodenough & Prehn 2004), this review focuses on the place of emotion in law and of punishment in human brains.

Law and emotion. Emerging work on that cluster of mental processes that we group under the label of emotion is a good example of how the new models of thought can bring new insights to old problems. Emotion in its traditional usage gathers several mental processes and experiences together under a single label, and neuroscience helps us to make some useful differentiations. To begin with, we can separate the sensation of arousal that we monitor in ourselves and others and label emotion from the functional mental processes that give rise to the sensation (e.g., Goodenough & Prehn 2004).

Neuroscience suggests that at a functional level, the processes that we label emotion act as a kind of emphasizer and highlighter in the brain, an indicator of importance and urgency (e.g., Rolls 1999, Dolan 2002, Phelps 2002, Morris & Dolan 2004, Baird 2009b). Emotional states direct our attention—our cognition gravitates toward phenomena that have emotional valence (Anderson & Phelps 2001). In the realm of memory, events that are accompanied by emotional states are more likely to be transferred from working memory to long-term recollection (Morris & Dolan 2004). This transfer, however, is no guarantee of accuracy; work by Phelps & Sharot (2008) has demonstrated that the feeling of certitude that comes with memories formed in an emotional context—such as our memories of the events of 9/11—is not justified by greater accuracy in such memories.

Recognizing the functionality of emotion allows us to understand its place in law. Richard Posner (1999), a rationalist who sees some role for emotion in moral and legal judgment, described the traditional suspicion of emotion in legal studies:

> The law itself is conventionally regarded as a bastion of "reason" conceived of as the antithesis of emotion, as operating to rein in the emotionality of the behavior that gives rise to legal disputes.

We now understand, however, that without an emotional content, much of the motivational force of normative judgment would be missing (Bandes 1999, Goodenough & Prehn 2004, Greene 2008, Goodenough 2009). Sunstein (2009) has noted the importance of indignation and moral outrage as motivators in the decisions of juries and in legislative decisions. Emotions may also act as guarantors of moral commitments, both in ourselves and in our judgments of others (RH Frank 1988, 2001, 2008). They are often a necessary part of competent thought, particularly thought that will lead to action. On the other hand, rationalists have a point: Emotion-driven reactions can impel us to responses that are not productive in the long run, a classic "Goldilocks problem" for the law (Goodenough 2009). Maroney (2006, 2009) is helping to further delineate the role of emotion in particular legal problems and processes.

Neuroscience of punishment. The debates over the nature and goals of punishment have a long history (e.g., Bentham 1830; for treatments of this history, see, e.g., Kenny 1978, Zaibert 2006). Cited rationales for criminal punishment include revenge, deterrence, rehabilitation, and incapacitation. These goals are sometimes further categorized as either consequentialist/utilitarian in nature, an approach linked with Bentham and Sidgwick, or as retributivist, linked with Kant and Hegel (Zaibert 2006). In recent years, punishment strategies in much of the world have been motivated by an increasing attention to data-driven consequentialism. The United States, however, has experienced the reverse. Here, recent trends have often been retributivist, "marred by a form of penal populism in which tough talk on crime has been seen by politicians of all parties as a precondition to electoral success"

(Roberts & Hough 2002, p. 3; see also Jacobs & Jackson 2010, this volume).

Some neuroscientific research has suggested that humans do indeed have a psychological propensity to inflict punishment on perceived wrongdoers (e.g., Fehr & Gächter 2002, Sanfey et al. 2003, Goodenough 2004, Fehr & Fischbacher 2004, Knoch et al. 2010; see review by Seymour et al. 2007). Evidence suggests that this response exists in many cultural contexts and thus may be some kind of human universal (Herrmann et al. 2008, see also Boyd et al. 2003). Jones & Kurzban (2007, 2010) point to the similarity in the rank ordering of blameworthiness of certain core crimes across many cultures as further evidence of universality in punishment judgments. The exploitation of such a propensity by politicians seeking electoral success could be at least part of the explanation for the "penal populism" noted by Roberts & Hough (2002), an effect also noted by Jacobs & Jackson (2010, this volume). Other research, however, has raised questions about the scope of this punishment predilection and the contexts within which it will be an effective strategy (e.g., Dreber et al. 2008). Certainly if there is a human taste for retribution and revenge, driven by emotion (Sanfey et al. 2003, Bandes 2007, Greene 2008) and deeply rooted in our psychological makeup, it is probably not always our most effective strategy for all perceived wrongs. As discussed above, emotion is a great goad to action, but it can also overdo the response. Law can help mitigate the "Goldilocks" problem of emotion in the context of punishment (Goodenough 2009).

In this mitigating light, law should consider punishment and sentencing for its effectiveness in addressing the wrong committed and seek to reconcile that with the needs for punishers and for the society in which they live to feel that the psychological desire for retribution has been satisfied. Neurolaw can make contributions to both halves of this process. For instance, as is discussed below, by exposing the cognitive impairments involved in addiction and mental illness and in the developmental stages of youth, we can both create more effective responses from a utilitarian standpoint and provide some basis for a more merciful imposition of the power of law on offenders in these categories.

Juveniles. Whatever our attitude toward punishing adults, there is strong evidence that most of us think differently when we punish juveniles. Something widespread in human psychology spares the rod, employs compassion, or at least inhibits our most severe reactions to a child's transgression, particularly in cases of low- to mid-level wrongdoing. The opinion of the U.S. Supreme Court in the recently decided case, *Graham v. Florida* (2010), shows this reluctance in more serious cases as well, at least to the extent of refusing to foreclose any possibility of future review of a life sentence for juvenile crimes other than homicide. Historical legal systems have incorporated special treatment for children. In Roman law, the license of youth, or *licentia juvenum*, referred to the special treatment of youth during the prætorian period of Roman Law (Ortolan 1870 [1871]). The modern equivalent of this notion is captured in the exculpatory statement that "boys will be boys," a sentiment that serves to excuse behavior that might well land an adult in jail. But it is also clear, from the controversy over the *Roper v. Simmons* (2005) case concerning the death penalty for murders by a 16- and a 17-year-old and more recently the consolidated cases in *Graham v. Florida* (2010), that the license of youth has limits. For really serious offenses, our unexamined willingness to excuse evaporates (Liptak 2009).

Psychologists, philosophers, and behavioral researchers have observed and explained our reticence to mete out harsh punishment to our young, citing developmental and evolutionary benefits (e.g., de Waal 2000, Fehr & Fischbacher 2004, Greene 2008). The neuroscience argument advocating leniency is often framed in terms of the incomplete development of youthful brains, and in particular the slow maturation of frontal lobes, often measured by the progress of myelination (e.g., Baird & Fugelsang 2004). Baird's (2009a) most recent work on developmental neuroscience and its implications for law suggests that limits on experiential learning are probably as important as the biological aspects of maturation. During adolescence, youth become more capable of regulating their thoughts and actions and of counterfactual thinking. She points out, however, that "this ability depends in great part on experience," making its development cyclical and uneven across situations. Adolescents need experience—and challenging experience at that—to learn the proper and legal path to take.

Thus, there is some justification for giving youth—and adolescents in particular—some space in which to make mistakes while their brains become more capable and properly trained against the lessons that mistakes can provide. The rationale, however, does not exist in a vacuum, but rather in a system of law created and enforced by adult thinkers. Framing it this way prompts us to query whether the license of youth reflects a widely shared psychology of withheld retribution and whether the exception for juvenile treatment under the law is a product of cultural norms, a rational process based on utilitarian ideas, or a deeply grounded psychological predilection. In other words, does the human mind have a propensity for a license of youth in the punishment context?

There is considerable evidence that the visual cues of youth—particularly infant or infantile faces—prompt drug-like dopamine responses in adult observers (e.g., Strathearn et al. 2008). A similar response in animals has been suggested by anecdotal observations of advanced primates by de Waal (1996). This research suggests a neural link between a child's physical development or appearance and a parent's innate nurturing behavior and, if scalable, possibly informs the historical prohibitions on severe punishment of child offenders. Although further research is necessary to answer the questions that such an approach raises, turning the focus onto the punisher and the goals of punishment provides opportunities to reframe the debate over how much to punish a youthful transgressor.

More nuanced punishments and other interventions for addiction and mental illness. Whatever license may be given to juveniles, when dealing with adults humans demonstrate an entrenched folk psychology of responsibility and guilt, accompanied by a complex taste for punishment (e.g., Greene 2008). As a result, we conclude that the responsibility phase of criminal prosecution is a psychologically poor place to argue for excuse based on neurological understanding of the sources of the offending behavior. We believe, instead, that the insights of neuroscience can be most usefully applied to criminal law reform at the stage of deciding how to deal with someone who has been found guilty. Garland & Frankel (2009) come to a similar conclusion (see also Hughes 2010).

The recent development of such tailored responses as drug courts (Nolan 2003, but see O'Hear 2009) and mental health courts (Erickson et al. 2006, Counc. State Gov. Justice Cent. 2008) shows a desire to get away from incarceration—and long incarceration at that—as the principal weapon in the anticrime arsenal. These developments had already been underway before neurolaw became incorporated into the mix, but neuroscience has helped to increase their effectiveness and accelerate their spread.

As Morse (2006a, 2009) points out, the debate over whether addiction is best viewed as a crime or as some kind of treatable illness or disease is not a new one, and neuroscientific approaches are entering into an established debate. Nonetheless, neuroscience is providing new perspectives on addiction in the drug context and beyond (e.g., Bonnie 2005; Morse 2006a, 2009; Hyman et al. 2006; Hyman 2007a; Erickson 2007; Charland 2007). Science is noting similar addiction patterns across substances (e.g., Nestler & Malenka 2004) and addictive behaviors without the component of an external substance, a span that can stretch from stimulants such as cocaine and sedatives such as heroin to activities such as sex or cutting.

The best target for a common denominator in the brain across these different kinds of addiction is the dopamine system. The most powerful among our problem drugs have strong impacts on this system, either through substitution (the opiates) or through reuptake suppression (cocaine). This system not only produces the pleasure reactions associated, at least in the early stages of addiction, with drug consumption, but it is also deeply connected with perceptions of reward and learning. As Hyman et al. (2006, p. 565) summarize the field,

> Clinical and laboratory observations have converged on the hypothesis that addiction represents the pathological usurpation of neural processes that normally serve reward-related learning. The major substrates of persistent compulsive drug use are hypothesized to be molecular and cellular mechanisms that underlie long-term associative memories in several forebrain circuits (involving the ventral and dorsal striatum and prefrontal cortex) that receive input from midbrain dopamine neurons.

In more accessible language, addictive drugs hijack the processes by which we learn what is good to do—giving a hard-to-combat neurochemical stimulation to the psychology of compulsive repetition. This insight helps us to understand the difficulties that criminalization alone faces in redirecting the cravings and behavior of addicts.

The result is not necessarily an excuse. Morse (2009) argues vigorously that our traditional models of responsibility should not be eroded in the face of an understanding of addiction-driven craving and even compulsion. As suggested above, the whole responsibility/neuroscience debate may be a bit of a red herring. Using the "do they do it in front of a police officer" test, we can conclude that most addicts have enough control over their needs and cravings not to indulge in contexts that will lead to immediate arrest.

But if the front-end question of responsibility may be unaffected, the mandated response of society through law to a convicted addict may be significantly changed when considered from a neurolaw perspective (Eagleman et al. 2010). Many jurisdictions are experimenting with drug courts, which permit a more nuanced and tailored approach to the challenges of recidivism and reform (e.g., Nolan 2003). New evidence-based practices are being applied to the postconviction supervision and treatment for addicts—whether on release or in prison (see generally Edmundson & McCarty 2006, Miller et al. 2006). Neuroscience is also beginning to supply treatments—drugs like naltrexone—that can, at least in many sufferers, effectively counteract the chemistry of addiction in various contexts (Bonnie 2006). By reenvisioning what we can do about addictions and helping spark the implementation of new strategies for those convicted of drug offenses, neurolaw can unlock some of the paralysis that has settled around the criminal response to problems of addiction.

Mental illness would also appear to be a field of study ripe for law and neuroscience collaboration, but, with the exception of a few bright spots, so far relatively little has occurred. The research that has taken place has often been linked to such criminally important conditions as psychopathy (Kiehl et al. 2004, 2006; Kiehl 2008; Gao et al. 2009) and pedophilia (Cantor et al. 2008). In this context, prediction is the goal. Can we develop diagnostic tools and physical and behavioral markers to identify, with acceptable accuracy, people who are likely to offend? Can we also develop more effective responses ranging from treatment to extended supervision in the criminal justice system? Kiehl's investigation of psychopaths is an excellent example of this research direction. His team has built a mobile scanner, mounted in a truck trailer, and they are in the process of scanning a significant share of the prison population in New Mexico (Seabrook 2008). While not yet developed enough to serve a mitigating role in particular criminal cases (Hughes 2010), the results of these studies have the potential to increase our accuracy of diagnosis for psychopathy and to suggest better interventions with this population of high-risk offenders.

What has been largely missing in neurolaw is an effort to engage with the legal problems of chronic mental illness of a less spectacular kind, such as depression, schizophrenia, and behavioral problems caused by brain injury. In part this is because the field is already occupied: There is already considerable activity at the intersection of law and mental health (e.g., Lamberti 2007), an area in which neurolaw scholar Stephen Morse has been particularly active (see, e.g., Morse 2004a,b, 2006b,c, 2007, 2009). If one of the principles for selecting targets for neurolaw is to seek areas where old approaches have not worked well, however, then mental health law could use the field's attention. How does cognitive neuroscience lead us to a better understanding of mental illness, and what impact may that have on law and policy? The first payoff in neurolaw may be in helping the public, lawmakers, and practitioners in the mental health support and criminal law communities to reconceive the nature of mental illness and to imagine new responses to someone whose mental health problems are leading to run-ins with the law (Bonnie & Monahan 2005; Greely 2008, 2009).

Neuroscience itself, through imaging and lesion studies, is helping to identify injuries or other impairments to the functional brain systems that can be identified through scanning (Grafman et al. 1996, Brown & Eyler 2006). For example, damage to certain regions associated with empathy, with rules compliance, and with moderating aggression or triggering inhibition have been found in subjects exhibiting antisocial behavior. This kind of damage can be due to physical trauma, as in the classic historical case of Phineas Gage (Harlow 1848, Damasio et al. 1994), childhood maltreatment (Widom 1989, Lewis 1998), or other stressors such as post-traumatic stress from war. Orbital prefrontal cortex damage is particularly implicated in trauma damage indicating a deficit in acquisition of moral and social rules (Anderson et al. 1999). Damage can also result from alcohol or other substance abuse (Leeman et al. 2009).

Other advances have come through neurotransmitter studies. Neurochemistry appears to be at the heart of many mental health challenges, ranging from depression (serotonin) to schizophrenia (dopamine, glutamate, and serotonin) (Sawa & Snyder 2002, Miyamoto et al. 2003, Stone et al. 2007). Research is leading to better understanding and improved treatments (Greely 2008). And responses by the legal system such as mental health courts hold promise for putting this new knowledge to work in positive ways (Erickson et al. 2006, Counc. State Gov. Justice Cent. 2008). This should be fertile ground for further work in neurolaw (Greely 2009).

THE FUTURE OF NEUROLAW

Early in this review, we asserted that the law and neuroscience combination has put down solid roots and is likely to persist and grow in the near future. We hope that this survey has supported our belief. In the longer-term future, however, neurolaw faces a core challenge, and it is not really one of substance. Rather, it is whether scientists and lawyers can collaboratively engage neurolaw questions in a process that satisfies both the rigorous demands of investigative science and the professional and ethical duties of the legal profession to produce results that further the interests of justice.

Neurolaw is, of necessity, collaborative work. Both of the constituent disciplines are complex studies, involving long training and a particular approach to the world. Mastering one of the fields is hard; obtaining mastery in both is very challenging indeed. Thus, most projects will need to rely on collaboration, and progress will require lawyers, scientists, and a smattering of helpers from such other disciplines as philosophy to talk and work together. This is certainly the structure adopted by such promoters as the Dana Foundation, the Gruter Institute, and the networks of the MacArthur Law and Neuroscience Project. It is also not always an easy structure to make work. Law has some deeply rooted peculiarities of conception and method that can be off-putting to scientists and philosophers alike.

This review has, for the most part, been written with a legal audience in mind: The emphasis has been on how neurological discoveries will challenge our legal system. But the challenges are, in fact, a reciprocal proposition. The interaction of law and science will also require the scientists involved to open themselves to new, and sometimes disruptive or even threatening, activities. At a basic level, many scientists are deeply reluctant to move from an abstracted and morally neutral world of research to the practical application of their work, whether in formulating policy and legal rules or in helping to decide specific cases of conflict and punishment. The stereotypical cartoon of the scientist as a detached, sometimes obsessive, egg-head has its roots in reality.

Although it appears obvious, one of the most important differences between law and many other branches of ethical study is its engagement with real dilemmas, opportunities, and controversies. There is nothing speculative about a criminal prosecution or, for that matter, about a tort claim, contract, property deed, or worker's compensation request. A corollary to this, particularly in litigation contexts, is that the law is constantly shaping its inquiries toward a decisive end, typically a yes/no answer of some kind. The contract is binding or it is not. The jury should convict or acquit. The property is owned by the plaintiff or it is not. While a legal question often begins with ambiguity (remember the famous lawyer answer "it depends"), the process is usually aimed at squeezing the ambiguity out of the question.

This drive toward a settled conclusion, often on woefully incomplete evidence, is a source of much frustration for scientists, who understand all too well the indeterminacy of their work and provisional nature of many of their findings. Furthermore, the contentiousness of legal and political processes is both unsettling to many scientists and, in some cases, a threat to their ability to continue their work. Much of science is funded by government or foundation grants. A scientist who takes a side in a politically visible cause like criminal reform runs the risk of jeopardizing future funding (Pielke 2007).

Furthermore, getting involved in the courtroom or in the legislative process opens a scientist to the unpleasantness of partisan attack. For example, the American Bar Association published a book by Stephen Easton (2008) entitled *Attacking Adverse Experts* with chapter and section titles that include "Battlefield Questioning Techniques for Expert Depositions," "Launching Your Attack," "Showing that the Adverse Expert is Wrong," and "Attacking the Adverse Expert's Credibility (Including Competence)." Sound like fun? No wonder the best scientists often prefer tooth extraction without anesthetic to putting their knowledge to work in a legal proceeding.

Nor is criticism of the application of neurolaw in the courtroom limited to legal attack. Putting his study of psychopathy to work in the courtroom, in October 2009 Kent Kiehl participated in a hearing on the death penalty for a convicted murderer and rapist (Barros 2010, Hughes 2010). He had scanned the defendant, Brian Dugan, as part of a diagnosis that sought to link his actions with psychopathy and that was offered to the jury in mitigation at the penalty stage. Kiehl was allowed to present his argument, although the judge did prevent showing pictures of the specific scan of Dugan's brain. The result was not only a demanding cross-examination in the courtroom, but also an article in *Nature* (Hughes 2010), in which Kiehl's decision and presentation were held up to support and criticism by his scientific peers.

The next stage of development for law and neuroscience will require an increasing number of scientists to emulate Kiehl, take the plunge, and join in the hurly-burly of cases, policy, legislation, and law reform. As suggested early in this review, the next stage in the interaction of neuroscience and society is the development of applications. And the quality of these applications will be directly linked to the quality of the science—and the scientists—that are being brought into the process.

There is a flip side to this challenge, and that is the limitations of the lawyers in the process. These include a reluctance or even inability to put aside existing paradigms of analysis. Consider the challenge from a scientist like Robert Sapolsky (2004) that the criminal justice system needs to be radically rethought, a challenge that helped to launch the MacArthur Law and Neuroscience Project. We on the law side are too often ready to process things to death and to digest a big challenge down into smallish reforms that will leave the status quo largely intact. We also sometimes justify our current legal categories by the simple, if circular, step of citing their existence in the law. Such conservatism has its place, but so, too, does a conceptual leap into new ways of doing things. If scientists are sometimes too concerned by controversy and reluctant to make consequential decisions based on limited knowledge, lawyers are sometimes too bound by current paradigms to see the leaps that could be made in doctrine and practice.

To reach its fullest potential, law and neuroscience will not just be about new discoveries in the brain; it will also be about new discoveries in cross-disciplinary collaboration. If we get this part right, then, over time, the substance is likely to take care of itself.

SUMMARY POINTS

1. Law and neuroscience have become an established interdisciplinary area of study, abbreviated by some as neurolaw.
2. The important developments of neuroscience include advances in technology, a better understanding of the physical processes involved in thought and action, and improved cognitive models.
3. These developments hold the promise of answering questions about law and policy that have been difficult to resolve based on traditional models of academic and folk psychology.
4. Because the science is still developing and because of opportunities for abuse, we should proceed cautiously as neurolaw develops.
5. Neurolaw scholarship has largely focused on issues of criminal law and courtroom use.
6. Free will approaches are not ultimately helpful in considering questions of criminal responsibility and punishment.
7. By changing our perceptions of drug use and mental illness, there is the potential for creating new and more effective responses to criminality growing from these factors.
8. The future success of the law and neuroscience interaction will not just be about new discoveries in the brain; it will also be about new discoveries in cross-disciplinary collaboration.

FUTURE ISSUES

1. The future of neurolaw will include the development of applications for law and policy, such as prediction tools and data-based interventions of treatment and punishment.
2. The field will move beyond the current focus on courtroom uses and criminal law.
3. Neurolaw scholars must help to develop better patterns of interaction between law and science.

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