Seven Ways Neuroscience Aids Law

Owen D. Jones*

The Game

Law is stuffy, bookish, and boring. Or so many people think. But forget, for a moment, the impressions of law that often come first to mind. Wood-paneled courtrooms. Dusty texts. Numbingly impenetrable language. Gesticulations at a podium.

Now think of law instead as a thrilling, massively multi-player game in which vast resources are at stake, alliances form and dissolve, betrayals and cheating are ever-present threats, arsenals are verbal as well as physical, and the safety of self and property must be navigated with care, en route to some shifting and precarious approximation of peace, happiness, and the acquisition of cool homes, reputations, and gadgets.

It is not my purpose, in prompting this mental shift, to trivialize or glamorize. It is to help us view law from 1,000 meters, so as to see the larger themes – and action-packed patterns – that reveal and define the deeper realities.

In a meaningful way, law *is* a game. There are rules. They are numerous. They are complicated. People have goals that cannot all be satisfied. Choices must be made, turns taken, and consequences – both predictable and not – endured. Each move inspires countermoves that, as in chess, change the strategic landscape of the game forever. And each player adapts to both minutely local and broadly systemic developments. The ecology of law is therefore and inevitably dynamic, fluid, high-stakes, and (often) intensely strategic. And far from being mere entertainment, the game is deadly serious.

This fundamental drama, this surge of human cooperation and competition, is not confined to the familiar domains of crime-scenes and courtrooms. It also pulses out along the web-like threads, in tangles too thick to trace, that constitute the multiple social affiliations of friends, colleagues, businesses, religions, interest-groups, political parties, and the like that so distinctly characterize our ultra-social species.

* New York Alumni Chancellor's Professor of Law & Professor of Biological Sciences, Vanderbilt University; Director, MacArthur Foundation Research Network on Law and Neuroscience.

Law is of course not the only source of potential order in this elsewise chaos, a circumstance vividly and physically illustrated by and within the Vatican City walls that circumscribe our conversation here today. Moreover, there can be wisdom in crowds. For even outside, before, or beyond legal prescriptions, people try things. They notice common interests. And various norms ensue.

But law is *a* source of order, whether it serves a regularizing function (everyone must drive on the same side of the road), an exchange-facilitating function (know ye this: here are the enumerated prerequisites for a contract to be enforceable), a peace-securing function (don't hit people), or the like. And although law is of course a form *of* human behavior it is also manifestly – and most importantly – a system *for regulating* human behavior.

Which brings us to brains.

The Brains

The human animal is numbered in multiple billions. And the game needs certain minimum efforts at order to keep physical force or possession from being the only human measures that matter. Law exists because there are significant interstitial spaces in the behavioral landscape between those places where everyone is already behaving just fine. More pointedly: Law exists mainly to effect *a change in behavior* from how people would have been behaving in the absence of legal intervention – that is, in the absence of some message to the public either about the content of some legal policy (such as: now you may deduct from taxable income the value of your charitable contributions) or about the tools law will use to incentivize behavioral change (such as: from now on, all fines for speeding are tripled).

Which is where brains – and ultimately neuroscience – come in. Because law is, at base, about changing behavior, and because behavior, at base, comes from brains, it follows that deeper understandings of the relationships between brains and behaviors (and, relatedly, about perception, judgment, decision-making, and the like) may aid efforts to increase the effectiveness, efficiency, and justness of law (Jones & Goldsmith, 2005).

To illustrate this central point, I have in the past invoked the metaphor of law as a lever (rather than carrot or stick) for moving behavior. That lever has, as its mission–critical fulcrum, a behavioral model (Jones, 1997; Jones & Goldsmith, 2005). The behavioral model, in turn, is comprised of the algorithms (formal or, much more commonly, informal) by which we predict that if law moves *this* way people are most likely to respond in *that* way, rather than in some *other* way. The key point is that when the lever of law is paired with an inaccurate behavioral model it makes for a soft and inefficient fulcrum at best, and it unintendedly yields disastrous behaviors at worst.

This image helps to explain why the legal system could be described (in a different metaphor) as a monstrously large and ravenously hungry consumer of the various behavioral models offered up by other disciplines. In law theory meets practice. And therefore lives – as well as property, businesses, and even regimes – are lost, saved, or changed when behavioral models are wrong, weak, or insufficient given the leverage society needs.

Law's behavioral models, historically and indeed to date, obviously vary a bit across the specific behaviors at issue, and sometimes reflect multiple models simultaneously. But, broadly speaking, they have included such things as: folk-psychological models (in which a person's actions can be predicted as a function of his or her desires and beliefs) (Nichols, 2002; Davies & Stone, 1995; Morse, 2008, 2011a); informal projections, from introspection, about other people's emotional, analytic, and motivational realities (e.g., "What would incentivize me?"); the sequential installation of one dominant disciplinary view (such as economics) after another (typically to the exclusion of other disciplinary perspectives) (Jones & Goldsmith, 2005); or an amalgam of several close cognate disciplines (such as psychology and sociology) (Jones & Goldsmith, 2005).

But we haven't yet learned nearly enough about why humans behave as they do and what can inspire them to change – as each day's news, whether international or local, so depressingly details. My view has long been that improving the behavioral models on which law relies requires far more aggressive efforts than we've deployed so far to formulate workable syntheses of balkanized fields, not only across the divide that separates the sciences and the humanities, but also within each of those too-separate domains (Jones & Goldsmith, 2005).

I am not the first to observe that the pace of discovery and the volume of ever-increasing knowledge have driven individuals into knowing more and more about less and less, as depth of knowledge inevitably trades against breadth (e.g., Wilson, 1998). Within biology, for example, those studying the same animal at either the ethological or the molecular level can barely talk to one another anymore, so great now are the divides between the methods, vocabularies, and knowledge of these subfields. But for models of human behavior to be accurate and robust, some inward-pulling force must bring the human behavioral disciplines to the very same table. And to that (round) table, I am convinced, must be more systematically added the various life science disciplines – to join with the existing social science disciplines on which law has to date too-exclusively depended.

Species-typical brains develop, through the construction and activity of neurons, at the intersection of genes and environments, as those encounters

are shaped by evolutionary processes over evolutionary time. Behavior is fundamentally a biological phenomenon. Consequently, developing a much deeper and more interdisciplinarily coherent understanding of why people behave in the patterns they do may aid our collective pursuit of an increasingly fair, effective, and just legal system. That may (and in my view probably does) require, at a minimum, increased attention to such fields within behavioral biology as behavioral genetics, evolutionary biology, evolutionary psychology, and neuroscience. Our purpose here focuses on the latter, to which I turn next.

The Relevance of Neuroscience to Law

There are two primary ways that neuroscience can be relevant to law: 1) it can pose new problems; and 2) it can offer aid in solving existing problems.

New Problems: Neuroscience and Legal Headaches

Neuroscience can pose new problems in the same way that many so-called "disruptive" technologies can. For example, given that technologies (such as functional magnetic resonance imaging (fMRI)) enable us to learn something about a person's brain *non-invasively*, could a brain scan by a government ever be characterized as an illegal search and seizure (Farahany, 2012; Shen 2013)? Is a brain scan more like taking a photograph of a person, or more like taking a hair sample for DNA analysis purposes?

When drugs that can enhance cognitive abilities (such as modafinil, which can be used medically for sleep disorders or attention deficit hyperactivity disorder (ADHD)) are used in non-medical settings, by people without medical need, to improve performance on competitive tasks (which is reportedly happening with increasing frequency) should the legal system sit idly by, or instead develop new responses?

What about non-drug technology that can enhance performance, such as the so-called implantable "neuroprosthetics" under development (Hampson *et al.*, 2012; Donoghue *et al.*, 2007)? To what extent should law – distinct from other forms of social order (such as religion, norms, or the like) grapple with the implications?

Or suppose the victim of a violent crime immediately takes a memory-dampening drug, such as propranolol. Should the legal system discount the victim's subsequent identification of a suspect? In an analogous civil case, should the system discount a plaintiff's amount of pain and suffering, on the theory that the drug diminishes it? Should those who failed to take the drug have their recoveries discounted, for failure to mitigate their damages (Kolber, 2006)?

New technologies can also pose distinct problems for judges who must divide the admissible evidence from the inadmissible. In the United States, for example, the last several years has seen both state and federal judges grappling with whether to admit into evidence the results of lie-detection tests that used fMRI technology (*US v. Semrau*; *Maryland v. Smith*).

So one key thing to watch for, in coming years, is instances when law is forced to face novel questions driven by novel technologies. For now, however, I want to focus our attention on the second kind of relevance: when neuroscientific insights or findings may provide direct value to the legal system, as it goes about trying to pursue the goals society assigns to it.

New Aid: Seven Values to Law of Neuroscience

As I see it, neuroscience can provide value to law in at least seven different ways.

Category 1: Buttressing

The scientific enterprise is one that – in the broader scheme of things – takes as long as it takes to get things as right as it can. Experiments provide the evidence on which best approximations are based. And inconclusive experiments can be followed by different or better experiments.

In contrast, the legal system rarely operates within an explicitly experimental paradigm. Instead of going back to the drawing board until more knowledge can be acquired, policy-makers, judges, and others in the legal system must often and quite unavoidably take definite action when the state of knowledge remains something far, far short of the scientifically familiar $p \leq 0.05$.

A defendant must be convicted or let go. A plaintiff who may have been injured by a corporation's action must succeed and get paid or not. New investigations for finding further facts would be just lovely to have. But the facts are generally either not amenable to discovery through experimental means (as in: was the driver negligent in not noticing the pedestrian crossing the road in the night?) or, even when new facts are amenable to discovery, courts are simply not in the business of designing or ordering new experiments in furtherance of truth.

In law, in addition, the best decision that can be made, with the limited evidence one has, must be made on the timeline society expects. Trials are not designed to discover new truths about the world, as science is. As David Faigman has succinctly put it: "While science attempts to discover the universals hiding among the particulars, trial courts attempt to discover the particulars hiding among the universals" (Faigman, 1999). Trials are therefore

designed to provide the most just result that can be reached, regarding a typically unique set of facts … *given* the constraints of time, resources, uncertainties, and the vagaries of evidence – which is generally and regrettably dependent on the self-reported memories of parties who are imperfect at best, and self-interested at worst.

The consequence of all this is that decisions are often made on the basis of evidence that leans *sufficiently* strongly in one direction. (In the United States, for example, different decision thresholds – such as *beyond a reasonable doubt* or *by a preponderance of the evidence* – formally accompany different legal contexts). But because many different forms of evidence can be weighed (and often are weighed) together, neuroscientific evidence (assuming the judge finds it relevant and not unduly prejudicial to unbiased decision-making) can fit quite comfortably within the system, just like any other form of evidence to consider and weigh. My point is that neuroscientific evidence – whether advanced in individual trials, for legislative purposes, or the like – is rarely if ever going to be the sole form of evidence that is relevant to a legal decision.

In some cases, for example, neuroscience might "only" point in the same direction as other evidence. And in those cases we might call this a "buttressing" function, inasmuch as the neuroscientific evidence collaterally supports, and further strengthens, something that already stands independently (or nearly so).

But even if the neuroscientific evidence doesn't change the *outcome* in such a circumstance, it is worth noting that it still changes the context. And that can provide an important advantage to the legal system – in the same way that four different and independent methods for reaching a similar conclusion can provide better support for that conclusion than would just one or two methods alone. (Recall, for instance, the famous triangulation from multiple research streams that Charles Darwin deployed in his *Origin of Species* (1859)).

Here is a concrete example. Suppose a person behaved in a criminally violent fashion, was arrested, and is now to be tried. The circumstances are bizarre and seemingly motiveless. The defendant looks "off" – in the eyes and facial expressions – even to strangers viewing still photographs of him. Witnesses attest that the defendant not only behaved out of the norm for law-abiding people, but also out of the norm for those who are criminally violent. Other witnesses report that the defendant, for at least the past year, was in such a worsening state of bizarre behavior that mental illness was strongly suspected. A clinical psychiatrist interviewing the defendant concludes that he is medically insane. And – to the point – a structural brain

scan (such as an MRI), a functional brain scan (such as PET), or both, reveal an extremely large tumor impinging on those regions of the prefrontal cortex commonly associated with the ability to inhibit and self-regulate.

In such a circumstance, what can we say of the value to law of the neuroscientific evidence? What we can say is that it can be quite valuable, even if it is not what lawyers call "dispositive" by itself. That is, by triangulating with other forms of evidence, the neuroscience increases confidence in the conclusion that the defendant was less responsible for his (not necessarily excusable) behavior than is the average similarly-aged citizen. Although this does not tell us what to do with such a person, the neuroscientific buttressing adds value to our deliberations.

Category 2: Challenging

In contrast, there may be times when neuroscientific evidence is either in tension with some other evidence or is in tension with some assumptions undergirding the entire legal context and approach. This function of neuroscience – which could run along a continuum from *calling-into-question* to *challenging* to outright *contradicting* – can add value to law's efforts to avoid error. That is, the neuroscientific findings may prompt useful course-corrections in a legal procedure, or may even prompt reforms in a legal policy or approach (Morse, 2011b).

Suppose, for example, that an assumption that underlies a particular feature of law is incorrect. A colleague of mine, Michael Vandenbergh, noticed that a provision of the *Federal Rules of Evidence* in the United States provides a valuable heuristic in this regard. Those rules prohibit, generally speaking, the admission of Bob's testimony – regarding a statement made by Charles about the existence of Fact X – if Bob's testimony is being introduced in an effort to prove that Fact X exists. (Fed. R. Evid. 801(c)). The principle rationale for the rule excluding such testimony is that the opposing party can't confront Charles directly about the basis of his own statement, which is merely "hearsay" when offered by Bob.

Yet among the exceptions to the exclusion of hearsay evidence is one for so-called "excited utterances". An excited utterance is "A statement relating to a startling event or condition, made while the declarant was under the stress of excitement that it caused" (Fed. R. Evid. 803(2)). Excited utterances are admissible – even when offered by those who merely overheard them – because they are considered unlikely to be deceptive. As the U.S. Supreme Court stated in *Idaho v. Wright*, "[t]he basis for the 'excited utterance' exception … is that such statements are given under circumstances that eliminate the possibility of fabrication, coaching or confabulation, and

that therefore the circumstances surrounding the making of the statement provide sufficient assurance that the statement is trustworthy and that cross-examination would be superfluous''.

The excited utterance example highlights the legal system's frequent dependence – typically without knowing it – on what are, at base, *neuroscientific* assumptions. Beneath the excited utterances exception to the hearsay rule, for example, is the implicit assumption that human brains just don't work with sufficient speed, or at least with sufficient speed when one is in a state of excitement, to afford a reasonable opportunity to lie. Leaving aside the fact that being in a state of excitement may very well interfere with the accuracy of one's perception, the legally operative assumption that people can't lie quickly when excited is testable (at least in theory). And it may very well be completely wrong. Consequently, any strong neuroscientific showing to that effect could potentially lead to valuable reform of the legal rule.

A wide variety of other assumptions in the evidentiary rules could similarly be called into question, given appropriate neuroscientific findings. For if there is one place in the legal system where rules are quite systematically a function of our shared understandings of what will probably happen in another person's brain it is in the evidentiary rules. Those rules enable a judge to prevent jurors from seeing or hearing certain kinds of information when there is reason to believe that jurors are likely to have their judgments compromised in one or more ways. Put another way, the evidentiary rules are quite inevitably built on assumptions about what happens, and with what consequences, when certain kinds of information get into a juror's brain. (For more, see Brown, 2012).

This example, within the context of evidentiary rules, is but one illustration of the broader point I want to make about the *Challenging* category. And that is that any time well-executed and properly interpreted neuroscientific developments strongly challenge important assumptions on which a given feature of law relies it can add value by virtue of such challenges. It may help the legal system avoid error, and might prompt useful reform of approaches based on faulty assumptions.

Category 3: Detecting

Into my third category fall all manner of valuable contributions of neuroscience that involve detecting, better than could previously be done, facts that are legally relevant. Better methods for detecting the extent of brain injuries (through structural and/or functional scans) would be a paradigmatic example. So, too, would be the use of fMRI or EEG for lie detection purposes (should the techniques advance that far) (Wagner, 2010; Shen &

Jones, 2011; Greely & Illes, 2007). The same is true for detecting autobiographical memories (say, recognition of pictures of a particular terrorist), or for detecting and quantifying subjective pain.

Those illustrations (repeated within this larger set, for convenience) multiply easily:
− How injured is this person's brain, and with what functional consequences?
− Is this person lying?
− Does this person recognize this target stimulus (e.g., a person's photograph)?
− How much pain and distress is the litigant feeling?
− What capacity did this person have to act differently than she did?
− Is this person mentally ill?
− What does this person remember?
− How accurate is this person's memory?
− What was this person's probable mental state, at the time of the act?

Adding to the corpus of potentially relevant facts, by detecting things that are otherwise undetectable, can in suitable instances aid the legal system's efforts to answer some of the big and perennial questions.

Category 4: Sorting

The legal system is frequently called upon – in both criminal and civil contexts – to sort people into categories, such as free or incarcerated, death-penalty-eligible or not, sane or insane, deserving of compensation or out of luck, … even dead or alive. In some contexts, neuroscience can offer aid with that sorting.

In criminal contexts, for example, one of the hardest problems to solve in law is this: How do you minimize the sum of the total societal costs of incarcerating a criminal and later returning him to society? Longer incarceration is costly (in taxes); but so is recidivism (in criminal activity). The latter costs are more vivid to the public, though not necessarily greater. One of the ways neuroscience can help the legal system minimize the total costs is by improving law's ability to sort people into groups that perhaps should be treated differently under the law. For example, neuroscience might help to illuminate the extent to which a particular defendant, or indeed certain kinds of defendants (addicts, for example, or juveniles), might respond more effectively to medical treatment, or to special treatment, than to standard-style incarceration.

In civil contexts, neuroscience can provide, for example, and indeed has provided, one useful measure, "brain death", for sorting the legally alive

from the legally dead (e.g., New Jersey Declaration of Death Act). Given the shortage of organs available for donation, and the advantages of removing organs from a body that is still metabolic active, defining the precise moment of legal death has very important legal (as well as social and medical) ramifications.

Category 5: Intervening

Another way neuroscience can help the legal system minimize the total costs of incarceration and reintegration is by offering new and effective interventions. For example, psychopharmacological neuroscience might present new drugs, with new capabilities, that can help to meaningfully reduce the incidence of certain kinds of recidivism.

Interventions come in many kinds. And the use of neuroscience to recommend an intervention does not necessarily imply that the intervention must itself also be neuroscientific – as would be psychopharmacological intervention or even (in theory) invasive techniques similar to those used in the deep brain stimulation (DBS) techniques for combatting Parkinson's disease or major depression. Many valuable interventions will continue to be strictly behavioral ones, for example through targeted courses of education and training, or through specialized techniques of behavior modification (also known as applied behavior analysis (ABA) or positive behavior support (PBS)).

Category 6: Explaining

There are times when neuroscience may help to explain or illuminate matters that, though not actively contested, have previously been beyond the reach of technological investigation. For example, colleagues and I at Vanderbilt University have used neuroscientific methods (fMRI) to reveal the brain activity underlying the decisions whether or not to punish and, if so, how much (Buckholtz *et al.*, 2009; Jones *et al.*, 2009). Studies like these, which may illuminate brain regions and neural patterns correlated with various aspects of legal decision-making, may ultimately help the legal system to learn more about pathways by which inappropriate biases can infect decision-making. And this in turn might facilitate efforts to combat such biases. Similar advances in explaining other law-relevant phenomena may provide the basis for adding value in other categories as well, such as in pointing a path toward effective interventions, or toward improved prediction of future behavior.

Category 7: Predicting

Neuroscience can also help law to the extent it can improve law's ability to make predictions. Some of these predictions may be about the amenability of a particular defendant to treatment (demonstrating, by the way, the inherent overlap between categories – in this case between *Predicting* and *Sorting*), or about the future behavior of individuals or groups.

For example, some of the most challenging questions the legal system routinely faces are ones like this: Given what this person did, the circumstances under which he did it, his nature as nearly as can be discerned, and his behavior while in custody, what is the likelihood that, if released, he will commit another violent crime? Biomarkers (structural, functional, or both) that neurosciences may discover might – in combination with other forms of knowledge, such as behavioral genetics, social psychology, clinical psychiatry, and the like – improve the accuracy of predictions about recidivism (e.g., Aharoni, *et al.*, 2013). In such a case, neuroscientific information could add considerable value to parole decisions, for instance.

The Non-Delegable Duty

This very brief taxonomy of some of the ways that neuroscience may prove valuable to law is subject to one over-arching principle. And that is that the legal system cannot delegate to another field, scientific or otherwise, the ascription of legal meaning. By this I mean that – even assuming that scientific testimony is unanimous as to a particular fact – the *legal* meaning of that fact is inevitably, unavoidably, and unshirkably a decision that legal decision-makers must bear. This is, in some respects, a formal legal application of *The Naturalistic Fallacy* (Hume, 1978; Moore, 1993), which underscores the important point of logic that facts never speak, all by themselves, to the appropriate normative conclusions. Put another way: an "is" cannot, by itself, yield an "ought", for the same reason that explanation is not justification, and that description is not prescription.

This is not to exaggerate the importance of law. I see neither law nor science as superior to the other, inasmuch as they have very different domains, purposes, and tasks. But it is important to draw a distinction between neuroscience answering a legal question and neuroscience *helping* to answer a legal question. At the same time that I think the former will be quite rare, I think opportunities for the latter are considerable, and quickly increasing.

The Endgame

The endgame of this discussion has one clarification and four main points. The clarification concerns the scope and nature of the taxonomy. Specifically, these seven usages – though distinct from one another – can and often will overlap in specific instances, given that a single neuroscientific result can often be used for more than one purpose.

Put another way, this set describes seven *forms of relevance*; it should not be thought to provide a rigid, over-reifying set of mutually exclusive cells in some hypothetical matrix that would divide the entire logical space (the various portions of which obviously can, in any event, be organized in multiple useful ways, see, e.g. Morse, 2011b). My four main points are these.

First, law needs neuroscience for the same reason it needs other life sciences: to deepen its understanding of the human animal in ways that may lead to more effective, efficient, and just regulation of human activities. A large and growing literature is making important contributions to this domain (*Law & Neuroscience Bibliography* (2013); Shen 2010; Morse & Roskies (in press)).

Second, the legal system will never reach its maximum potential if the behavioral models on which it relies are less complete than they might be, given further efforts to force reconciliation of differing disciplinary perspectives. Those who work in law should do all they can to encourage improved syntheses of disciplinary perspectives in the arenas of behavior most directly relevant to law.

Third, the legal system needs to gear up to confront the new legal problems and questions that neuroscience increasingly offers (Jones, Schall, and Shen, 2014). These questions are already appearing in the courts, where ignoring them is not an option (Jones & Shen, 2012). And this flow of new questions raised by neuroscientific techniques is far more likely to increase than to decrease.

Fourth and finally, there are a number of distinct ways – including at a minimum in the contexts of *Buttressing, Challenging, Detecting, Sorting, Intervening, Explaining, and Predicting* – that neuroscience can offer value to law. Though each of these contexts can afford real and tangible advantage to the fair and effective administration of justice, the specific pathways in which it may do so – and with what specific downstream implications – are yet to be fully identified and navigated.

Acknowledgments

References

Aharoni, E., Vincent, G.M., Harenski, C.L., Calhoun, V.D., Sinnott-Armstrong, W., Gazzaniga, M.S., & Kiehl, K.A. (2013). Neuroprediction of future rearrest. *Proceedings of the National Academy of Science, 110*, 6223.

Brown, T. (2012). The psychological presumptions underlying the federal rules of evidence. (working paper).

Buckholtz, J., Jones, O., Asplund, C., Dux, P., Zald, D., Gore, J., & Marois, R. (2008). The neural correlates of third-party punishment. *Neuron, 60*, 930.

Darwin, C. (1859). *On the origin of species by means of natural selection.* London: John Murray, Street.

Davies, M. & Stone, T. (eds). (1995). *Folk psychology: the theory of mind debate.* Cambridge, MA: Blackwell.

Donoghue, J.P., Nurmikko, A., Black, M. & Hochberg, L.R. (2007). Assistive technology and robotic control using motor cortex ensemble-based neural interface systems in humans with tetraplegia. *Journal of Physiology.* Special Issue on Brain Computer Interfaces*, 579,* 603–11.

Faigman, D. (1999). *Legal alchemy: the use & misuse of science in the law.* W.H. Freeman.

Farahany, N. (2012). Searching secrets. *University of Pennsylvania Law Review, 160*, 1239.

Greely, H.T. & Illes, J. (2007). Neuroscience-based lie detection: the urgent need for regulation. *American Journal of Law & Medicine, 33*, 377–431.

Hampson, R., Gerhardt, G., Marmarelis, V., Song, D., Opris, I., Santos, L., Berger, T., & Deadwyler, S. (2012). Facilitation and restoration of cognitive function in primate prefrontal cortex by a neuroprosthesis that utilizes minicolumn-specific neural firing. *Journal of Neural Engineering, 9,* 1–17.

Hume, D. (1978). *A treatise of human nature.* Dover Publications: Mineola, New York. *Idaho v. Wright*, 110 S. Ct. 3139, 3149 (1990).

Jones, O. (1997). Law and biology: toward an integrated model of human behavior. *Journal of Contemporary Legal Issues 8,* 167–208.

Jones, O. & Goldsmith, T. (2005). Law and behavioral biology. *Columbia Law Review, 105*, 405.

Jones, O., Buckholtz, J., Schall, J., & Marois, R. (2009). Brain imaging for legal thinkers: a guide for the perplexed. *Stanford Technology Law Review, 5.*

Jones, O. (2004). Law, evolution and the brain: applications and open questions. *Philosophical Transactions of the Royal Society, 359*, 1697–1707.

Jones, O., Schall, J., & Shen, F. (forthcoming 2014). *Law and neuroscience.* Aspen Publishers.

Jones, O. & Shen, F. (2011). Law and neuroscience in the United States. In Tade Spranger (Ed.), *International neurolaw: a comparative analysis* (pp. 349) Springer-Verlag.

Kolber, A. (2006) Therapeutic forgetting: the legal and ethical implications of mem-

ory dampening. *Vanderbilt Law Review, 59*, 1561.

Law & Neuroscience Bibliography, of the *MacArthur Foundation Research Network on Law and Neuroscience*, available at: www.lawneuro.org/bibliography.php

Mobbs, D., Jones, O., Lau, H.C., & Frith, C.D. (2007). Law, responsibility, and the brain. *PLOS: Biology, 5*, 693.

Moore, G.E. (1993). *Principia ethica*. Cambridge University Press.

Morse, S. (2011a). Avoiding irrational neurolaw exuberance: a plea for neuromodesty. *Mercer Law Review, 62*, 837.

Morse, S. (2011b). The status of neurolaw: a plea for current modesty and future cautious optimism. *Journal of Psychiatry & Law, 39*, 595.

Morse, S. (2008). Determinism and the death of folk psychology: two challenges to responsibility from neuroscience. *Minnesota Journal of Law, Science & Technology, 9*, 1–36.

Morse, S. & Roskies, A. (eds) (in press 2013). *A Primer in Criminal Law and Neuroscience*. Oxford.

New Jersey Declaration of Death Act, N.J.S.A. 26:6A-1.

Nichols, S. (2002). Folk psychology. In *Encyclopedia of Cognitive Science*. Nature Publishing Group, 134–140.

Shen, F. (2013). Neuroscience, mental privacy, and the law. *Harvard Journal of Law & Public Policy*, *36*, 653

Shen, F. (2010). Law and neuroscience bibliography: comments on an emerging field. *International Journal of Legal Information, 38*, 352.

Shen, F. & Jones, O. (2011). Brain scans as evidence: truths, proofs, lies, and lessons. *Mercer Law Review 62*, 861.

State of Maryland v. Gary Smith, Sixth Judicial Circuit, No. 106589C (2012).

U.S. v. Semrau, U.S. District Court for the Western District of Tennessee. No. 2:07-CR-10074-JPM (2011).

U.S. v. Semrau, U.S. Court of Appeals for the Sixth Circuit, No. 11-5396 (2012).

Wagner, A. (2010). Can neuroscience identify lies? In Wagner, A. (Ed.), *A judge's guide to neuroscience 13* (pp. 13–25).

Wilson, E.O. (1998). *Consilience: the unity of knowledge*. Knopf.