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Article 2

Neuroscience, Mindreading, and the Courts: The Example of Pain

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Our brains hold about 100 billion neurons.[1] At the synapses where neurons connect, the neurons are constantly giving off and picking up chemicals called neurotransmitters, which in turn can cause those neurons to "fire"—to run cascading ions down the neurons' "wires" or axons.[2] And that process creates the Universe we live in.[3]

Not quite, literally. I do believe, though I cannot rigorously prove, that you exist, the Earth exists, and the Universe exists outside of our own brains, but our only interaction with that reality is through our brains and the *physical* events that happen there. Those objective physical events create a subjective and non-physical "thing" we call the mind. If you remember tomorrow that you read this Article (or this much of the Article), it is because this Article (and I) will have made physical changes to your brain.

As we get better at looking at those physical changes in the brain through various new technologies, we can begin to correlate those objective physical brain states with subjective mental states.[4] We can begin to say

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1. Suzana Herculano-Houzel, *The Human Brain in Numbers: A Linearly Scaled-Up Primate Brain*, FRONTIERS HUMAN NEUROSCIENCE (Nov. 9, 2009), http://journal.frontiersin.org/article/10.3389/neuro.09.031.2009/full.

2. *See* HARVEY LODISH ET AL., MOLECULAR CELL BIOLOGY 935 (4th ed. 2000) (explaining the process by which a neurotransmitter, which originates at the presynaptic neuron, sends a signal when it is sent to the postsynaptic target cell).

3. *See* Robert Lanza, *A New Theory of the Universe: Biocentrism Builds on Quantum Physics by Putting Life Into the Equation*, AM. SCHOLAR (Mar. 1, 2007), https://theamericanscholar.org/a-new-theory-of-the-universe/#.VRIZjjTF-Hw.

4. *See* B. ALAN WALLACE, MIND IN THE BALANCE: MEDITATION IN SCIENCE, BUDDHISM, AND CHRISTIANITY 23 (2009) (noting the difference between objectively studying the brain and understanding the subjective mental state that is occurring simultaneously).

"any time you move the big toe on your left foot, these neurons fire," or "every time you see a face, those neurons fire."[5]

Consider, for example, some spectacular work by Professor Jack Gallant at the University of California at Berkeley.[6] Gallant's group showed thousands of hours of YouTube videos to some volunteers while they were in a magnetic resonance imaging ("MRI") scanner.[7] The MRI noted the changes at different times in the relative amounts of oxygenated and de-oxygenated hemoglobin in different parts of the volunteers' brains, in a process called functional magnetic resonance imaging ("fMRI").[8] Computers analyzed the resulting data and found correlations between what the volunteers were seeing at any given time and the patterns of these hemodynamic changes.[9] Gallant then took different volunteers, put them in the MRI scanner, and showed them trailers from movies.[10] His team took the resulting brain scans and, using the correlations from the original work, "re-created" the scenes from the trailers as the volunteers saw them.[11] The results are far from perfect—but still close to amazing. When, in a trailer, an elephant walks across a plain from left to right, the recreation of what the viewer sees from the viewer's brain scan shows something that looks like an elephant-shaped haystack walking from left to right across a plain.[12] The results come from correlating perceived physical states of the brain with

5. *See* Ferris Jabr, *Know Your Neurons: How to Classify Different Types of Neurons in the Brain's Forest*, SCI. AM. (May 16, 2012), http://blogs.scientificamerican.com/brainwaves/2012/05/16/know-your-neurons-classifying-the-many-types-of-cells-in-the-neuron-forest/ (noting that neurons are classified by function because neurons that carry sensory information are not the same neurons that carry signals for motor function in the body).

6. *See* Yasmin Anwar, *Scientists Use Brain Imaging to Reveal the Movies in Our Mind*, UC BERKELEY NEWS CENTER (Sept. 22, 2011), http://newscenter.berkeley.edu/2011/09/22/brain-movies (citing the cutting-edge work by Prof. Jack Gallant and his lab, which have successfully reconstructed humans' visual experiences through computer simulation as the participants watched Hollywood movie trailers); *see also* Shinji Nishimoto et al., *Reconstructing Visual Experiences from Brain Activity Evoked by Natural Movies*, GALLANT LAB @ UC BERKELEY http://gallantlab.org/publications/nishimoto-et-al-2011.html (last updated June 18, 2014) (explaining the use of an fMRI machine to measure brain activity during the experiment, and the computational models used to reconstruct what participants saw).

7. Anwar, *supra* note 6.

8. *Id.*

9. *Id.*

10. *Id.*

11. *Id.*

12. *See* Malcolm Ritter, *Mind-Reading Technology Reconstructs Videos from Brain*, SYDNEY MORNING HERALD (Sept. 23, 2011), http://www.smh.com.au/technology/sci-tech/mindreading-technology-reconstructs-videos-from-brain-20110923-1ko5s.html (noting that human forms were more recognizable in reconstructions, while figures such as elephants did not transition so clearly).

subjective mental states.[13] It comes from, in some small way, reading minds.

This Article is about mindreading and its applications to the law. We are beginning to be able to use neuroimaging and other techniques to read minds.[14] Most of the attention in the burgeoning field of law and neuroscience has focused on issues of free will and criminal responsibility, but the most important contribution that neuroscience will make to the law will be through neuroscience-based mindreading. And I suspect its first important use will be in the area of detecting "pain," on which this Article will focus.[15]

This Article makes that argument in four parts. First, it looks at what kind of evidence the law currently uses to read minds, and how neuroscience-based evidence would and would not be different.[16] Second, it discusses some of the possible ways the law could use neuroscience-based mindreading.[17] Third, in its most novel contribution, it analyzes what kind of proof the law should demand of the accuracy of such mindreading techniques—and what we would have to invest in developing these technologies to be confident in their use.[18] Finally, it touches on one of the deepest problems that might be raised by the use of accurate mindreading evidence in the law.[19]

13. Anwar, *supra* note 6.

14. *See* Rob Hoskin, *Can a Neuroscientist Read Your Mind?*, SCIENCE BRAINWAVES (Apr. 30, 2012), http://www.sciencebrainwaves.com/uncategorized/can-a-neuroscientist-read-your-mind/ (highlighting the neural information that occurs even before a decision is made).

15. The implications for the legal system of neuroimaging of evidence of pain is the subject of a small, but growing literature. *See* Adam J. Kolber, *The Experiential Future of the Law*, 60 EMORY L.J. 585, 651 (2011) (identifying the need for more objective units to describe certain experiences, like pain); Adam J. Kolber, *Pain Detection and the Privacy of Subjective Experience* 33 AM. J.L. & MED. 433, 453–54 (2007) (noting the need for more privacy for records regarding pain); Amanda C. Pustilnik, *Imaging Brains, Changing Minds: How Neuroimaging Can Transform the Law's Approach to Pain*, 66 ALA. L. REV. (forthcoming 2015); Amanda C. Pustilnik, *Pain as Fact and Heuristic: How Pain Neuroimaging Illuminates Moral Dimensions of Law*, 97 CORNELL L. REV. 801, 805 (2012) (highlighting that it is a major challenge to assign values to brain imaging, just as it is a challenge to do the same for pain when attempting to create law).

16. *See infra* Part I.

17. *See infra* Part II.

18. *See infra* Part III.

19. *See infra* Part IV. I have discussed some of these issues about mindreading twice before in some depth. *See* Henry T. Greely, *Neuroscience, Mindreading and the Law*, *in* A PRIMER ON CRIMINAL LAW AND NEUROSCIENCE 120–49 (Stephen J. Morse & Adina L. Roskies eds., 2013); Emily R. Murphy & Henry T. Greely, *What Will Be the Limits of Neuroscience-Based Mindreading in the Law?*, *in* THE OXFORD HANDBOOK OF NEUROETHICS (Judy Illes & Barbara Sahakian eds., 2011) (identifying the technical barriers to meaningful mindreading, including the likely impossibility of creating a complete model of the human brain). I have also discussed them in less detail in several other publications. *See* Henry T. Greely & Anthony D. Wagner, *Reference*

We are near the edge of neuroscience-based mindreading in the law. As two of my former Stanford post-docs said in an article, we currently see "through a scanner darkly."[20] We don't see clearly, but we see a little, and the resolution of the scanner, or at least our understanding of what it means, is getting better and better.[21] As our resolution and understanding of the scanners gets better, it will become more important in the law, in some ways discussed here and in others still unforeseen.

I. CURRENT EVIDENCE OF MENTAL STATES

Each one of us, in our day-to-day lives, reads minds constantly. So does the legal system. This section discusses the evidence we currently use for mindreading—in our everyday lives and in the law—with particular reference to how we understand another's pain. It then examines how these current methods are similar to and different from neuroscience-based evidence for mindreading.

A. Mindreading In General

This Article started as a lecture.[22] One tries to convey information in both a lecture and in an article, but unlike an article, a lecture is more like a conversation and full of mindreading. In any lecture, as with any other direct human interaction, I read the minds of my audience. I look to see

Guide on Neuroscience, *in* REFERENCE MANUAL ON SCIENTIFIC EVIDENCE 747–812 (National Academies Press, 3d ed. 2011) (discussing examples of possible uses and limitations of neuroscience in the courts); Henry T. Greely*, The Social Effects of Advances in Neuroscience: Legal Problems; Legal Perspectives*, *in* NEUROETHICS: DEFINING THE ISSUES IN THEORY, PRACTICE AND POLICY 245–63 (Judy Illes ed., 2006) (discussing different ways in which neuroscience affects our society, such as better prediction of behavior, improved detection of mental states, and enhancement of human brain functions); Henry T. Greely & Judy Illes, *Neuroscience-Based Lie Detection: The Urgent Need for Regulation*, 33 AM. J.L. & MED. 377, 413 (2007) (arguing for federal regulation of fMRI-based lie detection); Henry T. Greely, *Law and the Revolution in Neuroscience: An Early Look at the Field*, 42 AKRON L. REV. 687, 707 (2009) (pointing out that the "revolution" in neuroscience allows for better understanding of human brain processes and thus, better interventions in preserving or enhancing brain functions).

20. Teneille Brown & Emily Murphy, *Through a Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant's Past Mental States*, 62 STAN. L. REV. 1119, 1179–99 (2009) (discussing the reasons why functional brain imaging should not be admitted as evidence of a defendant's past mental state). Their title, of course, combines the title of the novel by the amazing Philip K. Dark, A SCANNER DARKLY (1976), with language from St. Paul's First Letter to the Corinthians, "Now we see through a glass, darkly . . . ." *I Corinthians* 13:12 (King James).

21. *See* Brown & Murphy, *supra* note 20, at 1144 (describing how magnetic resonance imaging scanners collect, process, and analyze functional imaging data).

22. Neuroimaging, Mindreading, and the Courts, The Stuart Rome Lecture, Imaging the Brain, Changing Minds: Chronic Pain Neuroimaging and the Law Symposium (Apr. 24, 2014).

who is awake, who is asleep, who is texting on their cell phone, who is confused, who is angry. I try to do this primarily by looking at faces, though also through examining some "body language," which is usually pretty limited when observing seated listeners.

In two-way verbal communications, either through face-to-face or by video-call, we read other people's minds in part through the content of what they say, and also through their facial expressions and tone of voice.[23] By telephone, we still have tone of voice but lose the facial cues. In e-mail or internet postings, we lose the tone of voice, which accounts for the popular and important use of emoticons to provide more clues for mindreading—was that a joke or not? (And, of course, the writer's problem is the inability to read the readers' minds, caused by the lack of any feedback from the readers.)

What we do in this day-to-day mindreading, of course, does not give us any deep or necessarily accurate insight into what the other person is truly thinking. We are looking at the outward appearance of that person through their physical states—facial configurations, pitch, and accent of words, and so on—and correlating that with mental states through our own experiences.[24] This experience can be with humanity in general, or with that particular person—"she is always angry when her nose looks like that."[25] We read minds through this correlation between objective physical states and subjective mental states.[26]

This is likely an ancient and crucial human survival trait, encouraged and preserved by evolution. It has been a long time since most humans have had to worry more about lions and tigers and bears than about other humans. The ability to guess whether the person coming toward you is about to share food with you or attack you is and has long been a vital survival skill.

23. *See* Jing Jiang et al., *Neural Synchronization During Face-to-Face Communication*, 32 J. NEUROSCIENCE 16064, 16064 (2012) (stating that nonverbal cues such as orofacial movements, facial expressions, and gestures are used to adapt our responses during communication).

24. *See, e.g.*, Peter Carruthers, *How We Know Our Minds: The Relationship Between Mindreading and Metacognition*, 32 BEHAV. & BRAIN SCI. 121, 121–22 (2009) (claiming that humans routinely and often unconsciously represent mental states using perceptions of others, forming expectations accordingly).

25. *See* Rana el Kaliouby & Peter Robinson, *Real-Time Inference of Complex Mental States from Facial Expressions and Head Gestures*, *in* REAL-TIME VISION FOR HUMAN-COMPUTER INTERACTION 181 (Branislav Kisačanin et al. eds., 2005) (stating that the human face is an essential and spontaneous means for communicating mental states).

26. *Id.* (explaining that facial expressions communicate feelings as well as cognitive mental states).

Some people lack that skill.[27] One of the great disabilities for many people with autism is that they do not develop what the psychologists call a "theory of mind."[28] They do not have feeling for what other people are thinking and often, as a result, have trouble getting along with others.[29]

Reading minds is very important.[30] We learn it from an early age, we use it every day, and we take it for granted. But what we are doing is taking accessible evidence of external physical states and using it to infer subjective mental states that are not directly accessible.[31]

We need no accessible evidence of external physical states to know if *we* are in pain. We either feel pain or we do not. Someone else might objectively conclude that, under the circumstances, we *should not* be feeling the, say, phantom limb pain. Or that observer might be certain that we *should* be in terrible pain from our own injuries in the car crash from which we are desperately trying to remove a loved one. But our pain does not need external indicia, at least to convince us. The pain is (or is not) our direct perception, proximately created by the firing of some of the neurons in our brain.

How do we decide whether other people are in pain? One way, of course, is to ask them, "are you in pain?" In most circumstances, if someone is not asleep, not unconscious, or not unable to understand or speak a common language with you, asking them is a good start. But it is not necessarily the end of the story—sometimes people do not tell the truth. As Hamlet said, "one may smile, and smile, and be a villain."[32]

The fact that people do not always tell the truth, or that sometimes they exaggerate, is something that we learn, usually to our disadvantage, very early in life. If people say they are in pain but we want further confirmation, what else can we do? We can, and do, look for external circumstances that

27. *Id.* (remarking that majority of people attribute mental states to persons from observed behaviors, and those who are not able to are at a disadvantage).

28. *See* Carruthers, *supra* note 24, at 136 (claiming that almost everyone believes that third-person mindreading is impaired in autism); Vivek Misra, *The Social Brain Network and Autism,* 21 ANNALS NEUROSCIENCE 69, 69 (2014) (discussing the "Theory of Mind" in autism, where there is an inability to infer the state of mind of another person)*; see also* el Kaliouby & Robinson, *supra* note 25, at 181 (citing that people diagnosed with autism spectrum disorders lack the ability to read minds of others).

29. Rachel C. Leung et al., *Early Neural Activation During Facial Affect Processing in Adolescents with Autism Spectrum Disorder,* 7 NEUROIMAGE: CLINICAL 203, 203 (2015), *available at* http://dx.doi.org/10.1016/j.nicl.2014.11.009 (stating that individuals with autism experience difficulties with social cues and understanding of another person's mental state, and thus have impaired social functioning).

30. *See* el Kaliouby & Robinson, *supra* note 25, at 181 (stating that mindreading is fundamental to social interaction, and it allows people to understand others' actions).

31. *Id.*

32. WILLIAM SHAKESPEARE, HAMLET, PRINCE OF DENMARK, act 1, sc. 5, ln.108.

correlate with pain. Some may be obvious causes of the pain while others may be predictable consequences of it.

For example, imagine someone has just been in a car accident. The jagged remnants of his femur are sticking out through the bloody wound in his leg as he screams wildly, while hopping frantically down the street to get away from the burning and possibly explosive car. That seems the kind of circumstantial evidence that would lead many of us to conclude that he is in pain. We see a wound that we would expect to cause great pain. We see behavior like screaming, wincing, avoiding putting weight on the injured leg that is consistent with a painful leg.

If, months later, you see that person again and he is limping, how do you interrogate his pain? You can ask him. You can watch him walk. Watching him limp could be consistent with him being in pain, but it could also be consistent with a false limp, or it could be consistent with a limp from a remaining structural flaw in his leg that is not painful. The limp is one piece of external evidence about his pain, but you could also talk to his friends. If one says "Pain? No, he never seemed to be in pain; he played five sets of singles tennis yesterday," that is some external evidence consistent with an absence of pain, though even that is not conclusive. The pain may be intense but intermittent, or pain may be eliminated by occasional use of strong drugs or very strong incentives. We use this non-direct, circumstantial evidence to try to draw conclusions about somebody's mental state with regard to pain.[33]

We all use these methods to read minds. We just cannot use them perfectly. After all, if we could read minds perfectly, poker would not exist, dating would be quite different, and negotiations would be much shorter.

B. The Law's Current Efforts at Mindreading

The law tries to read minds all of the time. "Was this premeditated?" "Was this done with malice aforethought?" "Was this reckless?" "Was this knowing?" "Did you realize that the bonds you were trying to sell were

33. For any readers who are or have been a parent of a small child, another example may be the way you determined whether your toddler was really in pain or was just seeking to manipulate other people, such as convincing you to discipline his or her sibling. The sounds, the apparent cause of the pain, the child's reaction to your reaction—all of these can help you assess just how real that pain was. *See* Lesley Budell et al., *Mirroring Pain in the Brain: Emotional Expression Versus Motor Imitation*, PLOS ONE (Feb. 11, 2015), www.plosone.org/article/fetchObject.action?uri=info:doi/10.1371/journal.pone.0107526&representation=PDF (stating that perception of pain experienced by another person has many channels through which the emotion and sensorium of another is communicated).

fraudulent?" All of these are questions about people's internal and subjective mental states.

Sometimes these are questions that the finders of fact can only assess by looking witnesses in the eye and trying to decide whether to believe them or not. But often, the law has other evidence that it believes correlates with relevant mental states. These may be recorded or remembered words that parties or witnesses said or wrote. Or it might be various actions that they took, like buying one-way tickets to Brazil the day before they got arrested. Or it could be various past events in their lives that may help establish motives or capabilities. All of these are external and objective pieces of evidence that the law uses to probe for witnesses' internal and subjective mental state.

Pain is one of the subjective mental states that the law most often needs to determine. Hundreds of thousands of legal proceedings each year in the United States turn on the existence and extent of someone's (usually a plaintiff's or claimant's) pain.[34] Sometimes those are personal injury cases, in which plaintiffs seek damages for their "pain and suffering" for the past, present, and predictably future in the aftermath of accidents.[35] Most of them are actually disability cases, brought under federal or state disability schemes, or against private disability insurers.[36] Although the technical question in those cases is not pain per se, it is quite often a question as to whether the claimants' pains are so great as to prevent them from working.[37]

The law will, when it can, ask the plaintiff or claimant whether or not he or she is in pain, but, with often substantial money at stake, the other side (the defendant, the disability program, or insurer) is not going to be

34. Pustilnik, *supra* note 15, at 802 (stating that pain is omnipresent in the law, and the presence and degree of physical pain are defined by various legal domains).

35. *See* Jack H. Olender, *Proof and Evaluation of Pain and Suffering in Personal Injury Litigation*, 11 DUKE L.J. 344, 344 (1962) (stating how past, present, and future pain and suffering are well recognized elements of damages in personal injury actions).

36. *See* Bureau of Justice Statistics, *Civil Cases*, OFF. JUST. PROGRAMS, http://www.bjs.gov/index.cfm?ty=tp&tid=45 (last visited Mar. 29, 2015) (stating that a large number of personal injury claims stem from medical malpractice and automobile accidents, and are brought in state or federal courts); *see* also THE FUTURE OF DISABILITY IN AMERICA 33, 437 (Marilyn J. Field & Alan M. Jette eds., 2007) (listing the different laws and avenues where people can bring disability suits).

37. Under Social Security Disability Insurance, the first question is whether you can resume the work you did before you became disabled. If the answer is "no," the next question is whether you can adjust to doing other work. *See* SOCIAL SECURITY, DISABILITY BENEFITS 9–10 (2014), *available at* http://www.ssa.gov/pubs/EN-05-10029.pdf (stating that the Social Security Administration asks several questions about a potential receiver's ability to work and how it is affected).

satisfied with only self-report.[38] Neither will the legal system.[39] Instead, the legal system will look for some external evidence to corroborate the claim of pain.[40] Just as we do in our day-to-day lives, the law will look for evidence about a plausible cause for the pain, as well as evidence from others about whether the plaintiff's or claimant's behavior has been consistent with that claimed pain.[41]

Sometimes, though, the law will also seek expert testimony.[42] A physician may be called to discuss the results of various kinds of imaging.[43] She may testify that the MRI of the person's back shows bulging intervertebral disks, which is consistent with the chronic lower back pain the person reports. Or the physician may state that her patient's PET scan shows that the patient's tumor has metastasized to the bones, and that severe pain is quite common in this circumstance. Or the expert testimony may not involve imaging at all. An expert witness might be called to testify how common it is for people who, for example, have had a hand amputated to feel continuing pain years after the amputation.[44]

For better or for worse, physicians are limited to providing evidence of objective, externally accessible facts (the bulging disks or the bone metastases) and their correlation (positive, negative, or neither) with the claimed pain.[45] They have no "pain meter" and no device that can directly

38. *See id.* at 7–8 (stating that in order to find benefits under social security, the applicant must provide all information and proof of disability, including substantial evidence such as medical records, names and dosages of medicine, and laboratory test results to support a potential applicant's claim).

39. Olender, *supra* note 35, at 367 (stating that it is advantageous to have medical experts support a plaintiff's claim).

40. *Id.*

41. *See id*. (stating that expert testimony is admissible and essential to recovery for damages where facts may not infer pain and suffering).

42. *Id.*

43. *See* AM. ACAD. OF NEUROLOGY, QUALIFICATIONS AND GUIDELINES FOR THE EXPERT WITNESS (June 25, 2005), *available* at https://www.aan.com/uploadedFiles/Website_Library_Assets/Documents/8.Membership/5.Ethics/1.Code_of_Conduct/Membership-Ethics-American%20Academy%20of%20Neurology%20Qualifications%20and%20Guidelines%20for%20the%20Physician%20Expert%20Witness%20%282%29.pdf (stating the elements of medical expert testimony for neurologists, including discussing imaging).

44. *See* Olender, *supra* note 35, at 359–60, 367 (explaining the concept behind "phantom pain," where amputees feel pain where the amputated part used to be, and that it may be explained through expert testimony in order to be compensated in personal injury actions); Vilayanar S. Ramachandran & Diane Rogers-Ramachandran, *Phantom Limbs and Neural Plasticity*, 57 NEUROLOGICAL REV. 317, 317 (2000) (explaining the phenomenon of a "phantom limb," where people may still feel pain despite amputation),

45. *See* Olender, *supra* note 35, at 366 (stating that most clinical work is not germane to proving the pain in an individual, and that physicians are limited in accurately measuring pain); *see also* Tonya Eippert, *A Proposal to Recognize a Legal Obligation on Physicians to Provide*

measure a person's level of pain. And that is often perceived as the promise, in the context of pain, of neuroimaging: that it might provide evidence, not of conditions that correlate with pain, but of pain itself. But that is wrong.

C. Neuroimaging Compared with Current Methods of Mindreading

How would the potential use of neuroimaging for mindreading compare to our more accustomed methods of mindreading? Very closely.

Neuroimaging, at least as it currently seems plausible, cannot provide direct evidence of the subjective mental state itself.[46] Instead, in its most discussed form (fMRI), neuroimaging provides direct evidence of the ratio of oxygenated to de-oxygenated hemoglobin in small cubic volumes of the brain (known as voxels), and of the changes in those ratios over time.[47] Those changes are then used to infer activity in particular brain structures, in a particular order, and, perhaps, in relative intensities.[48] Those activation patterns are then correlated with activation patterns of many people's brains when they reported (honestly, it is believed) their own subjective mental states of experiencing pain, of knowingly telling a lie, of feeling a particular emotion, or of recognizing an image as something they had seen before.[49]

As an example in the case of pain, the researchers will inflict upon the subjects some acute (but not damaging) pain.[50] Parts of their arms may have been smeared with capsaicin, the most active ingredient in chili

Adequate Medication to Alleviate Pain, 12 J.L & HEALTH 384–85 (1998) (stating the Texas Second District Court of Appeal's examples of objective evidence of injury that would support an award for pain and suffering, including skull and facial fractures and other various injuries).

46. *See* Russell A. Poldrack, *Inferring Mental States from Neuroimaging Data: From Reverse Inference to Large-Scale Decoding*, 72 NEURON PERSPECTIVE 692, 695 (2011) (stating that decoding methods cannot overcome neuroimaging's inherently correlational nature).

47. *See* Tor D. Wager et al., *Elements of Functional Neuroimaging*, *in* HANDBOOK OF PSYCHOPHYSIOLOGY 19, 21 (John T. Cacioppo et al. eds., 3d ed. 2007) (stating that fMRI uses the Blood Oxygen Level Dependent ("BOLD") method to measure the ratio of oxygenated to deoxygenated hemoglobin in the blood across regions of the brain).

48. *Id*. at 34 (stating that the inferential context for neuroimaging studies show the various regions that are activated).

49. Natalie Salmanowitz, *The Case for Pain Neuroimaging in the Courtroom: Lessons from Deception Detection*, 2 J.L. & BIOSCIENCES 139, 143–44 (2015).

50. *Id*. at 145 (explaining how infliction of pain assists in pain neuroimaging studies); *see also* Martin S. Angst et al., *Determining Heat and Mechanical Pain Threshold in Inflamed Skin of Human Subjects*, J. VISUALIZED EXPERIMENTS (Jan. 14, 2009), at 1–2, http://www.jove.com/pdf/1092/jove-protocol-1092-determining-heat-mechanical-pain-threshold-inflamed-skin-human (explaining the method of testing pain, which involved applying a heated metal plate to participants' skin and asking participants when they began to experience pain).

peppers, or touched with a heated metal rod.[51] They are asked to indicate whether they feel pain.[52] The MRI machine measures the hemoglobin ratios before and a few seconds after the stimulus, and its results are then analyzed through various complex statistical methods (notably those involving machine learning algorithms) to find patterns of activation that correlate with pain or its absence.[53] Similar experiments are involved in other mindreading fMRI approaches.[54]

Structural (as opposed to functional) MRI provides another possible method of mindreading. In this case, the actual size, shape, and density of various brain structures are measured.[55] Those measurements in an individual case could be correlated with the size and shape of those structures in other people who are known to have had a particular condition, such as Alzheimer disease or schizophrenia or pain.[56] Again, to use pain as an example, certain brain regions often are smaller than normal in people who have lived with chronic pain compared with other, very similar people who have not had chronic pain (the control group).[57]

51. *See* Christian Geber et al., *Numbness in Clinical and Experimental Pain – A Cross-Sectional Study Exploring the Mechanisms of Reduced Tactile Function*, 139 PAIN 73, 74 (2008) (stating how in certain pain experiments, capsaicin was applied to the right or left forearm in subjects); *see also* Angst et al., *supra* note 50.

52. *See* Angst et al., *supra* note 50, at 1 (stating that after applying the rod, study participants are asked when they begin to feel pain).

53. *See What Makes MRI Sensitive to Brain Activity?*, NUFFIELD DEP'T CLINICAL NEUROSCIENCES, http://www.ndcn.ox.ac.uk/research/introduction-to-fmri/what-is-fmri/what-does-fmri-measure-cont;d=Rk1SSUI= (last visited Feb. 27, 2015) (detailing the process of blood oxygenation level dependent ("BOLD") MRI which depends on hemoglobin ratios to detect small changes in brain activity to determine reactions to stimuli); *see also* Richard H. Gracely et al., *Functional Magnetic Resonance Imaging Evidence of Augmented Pain Processing in Fibromyalgia*, 46 ARTHRITIS & RHEUMATISM 1333, 1334 (2002) (noting that different types of brain scans now have a well-established history of being a useful tool for detecting if the individual is feeling pain).

54. *See* Gracely et al., *supra* note 53, at 1340 (showing fMRI results from a study of patients with fibromyalgia to determine how they processed pain differently from those without the disease).

55. *See* Carolyn Asbury, *Brain Imaging Technologies and Their Applications in Neuroscience*, DANA FOUND. (Nov. 2011), at 10, 12, https://www.dana.org/uploadedFiles/Pdfs/brainimagingtechnologies.pdf (describing the difference between a traditional MRI, which creates an image of the brain, and a fMRI, which "shows the brain in action").

56. *See* Martha E. Shenton et al., *A Review of MRI Findings in Schizophrenia*, 49 SCHIZOPHRENIA RES. 1, 6 (2001) (reviewing over a decade of research that used MRI technology to study the physical differences in brain structures between patients with and without schizophrenia).

57. A. Vania Apkarian et al., *Chronic Back Pain is Associated with Decreased Prefrontal and Thalamic Gray Matter Density*, 17 J. NEUROSCIENCE 10410, 10413 (2004) (discussing an early study that found that chronic pain sufferers had decreased gray matter compared to control subjects without chronic pain).

Various other methods, including electroencephalograms, CT (computerized tomography) scans, diffusion tensor imaging, and electrocorticography could also be used.[58] In every case, they would measure some objective physical (including electrical) state relevant to brain activity that would then be correlated with similar physical states in other people (or perhaps in the same person at other times) known, almost entirely by self-report, to be correlated with certain subjective mental states.[59]

This is not fundamentally different from how we and the law go about assessing someone else's pain. We look at objective, physical evidence—the sounds people make (whether words, groans, or screams), their behavior, and the past or present physical condition of parts of their bodies other than their brains (including sometimes imaging of those body parts)—that we believe are correlated with given mental states. Sometimes we get expert testimony about those correlations; other times we just use our own, often flawed, experience.

Neuroimaging evidence of mental states will usually, if not always, be like current evidence in another, important way: it will be used as one of several different lines of evidence. One of the areas where the discussion of neuroimaging-based mindreading often takes a wrong turn (which I have been guilty of myself) is by assuming the neuroimaging result is *the* definitive signal—something that, all by itself, conclusively demonstrates the existence or absence of the mental state in question.

That might, perhaps, occasionally be true, but it is much more likely that the neuroimaging will be one additional piece of independent evidence.

58. *See* Asbury, *supra* note 55, at 13–16 (defining the technical process of other neuroimaging techniques, such as electroencephalograms and diffusion tensor imaging, and their common uses in comparison to different types of MRIs); *see also* M. Demitri, *Types of Brain Imaging Techniques*, PSYCH CENTRAL, http://psychcentral.com/lib/types-of-brain-imaging-techniques/0001057 (last visited Mar. 14, 2015) (describing how CT scans work to show the "gross features" of the brain).

59. *See* John-Dylan Haynes & Gearing Rees, *Decoding Mental States From Brain Activity in Humans*, 7 NATURE REVS. 523, 530 (2006) (cautioning that while neuroimaging is advancing to the point that brain activity could be mapped and, in some cases, attributed to certain mental states, it is currently difficult to generalize that information because such comparisons between people are not yet reliable). The polygraph is an interesting example of how a scientific test could be used to demonstrate a mental state in court. It measures a variety of physical states, including pulse rate, breathing rate, blood pressure, and galvanic skin response (sweaty palms), all of which are correlated with the emotion of nervousness. *See* Greely & Illes, *supra* note 19, at 386 (detailing the physical conditions that a polygraph machine can measure). Polygraphs are not generally admissible in court because those correlations are not considered strong enough. But they are in admitted in court in some instances, and are used more broadly in administrative proceedings or other law-related contexts. *Id.*; *see generally* NAT'L RESEARCH COUNCIL, THE POLYGRAPH AND LIE DETECTION (2003) (discussing the scientific evidence of the polygraph).

Brains are complicated and individual.[60] It is unlikely that everyone's brain will react the same way to exactly the same stimulus, particularly with a complex stimulus or behavior.[61] It is more likely that, at best, an expert testifying about the implications of an fMRI scan with respect to the subject's subjective feeling of pain will be able to say something like "when we see this pattern of brain activation, in similar circumstances, 90 percent of people we believe to be honest report that they're in pain. When we take people who report, we think honestly, that they are not in pain, we only see this pattern five percent of the time."

That evidence would then be considered along with plaintiffs' or claimants' self-reports, other reports of their behavior, evidence about the presence or absence of some physical condition correlated with the existence of pain, and so on. Neuroimaging may well be strong evidence, but it is very unlikely to be perfect.[62] If we saw a person whose leg had just been broken, screaming in apparent agony and avoiding any pressure on that leg, we would likely (and rightly) dismiss a simultaneous fMRI study (assuming that were possible) that showed a very low likelihood of pain. In neuroimaging, as in our day-to-day world, we may read minds, but not perfectly. It will, at least some times, be one added piece of evidence that the triers of fact should consider in reaching a decision.

Forensic DNA, the great breakthrough in scientific evidence in the last several decades, provides a somewhat unfortunate parallel for forensic mindreading. Forensic DNA, the use of a person's DNA variations to identify him as the same or different person from the person who left a DNA sample, is much closer to perfect than mindreading is or is likely ever to be.[63] The chances of a match between any two random people are,

60. *See* Douglas B. McKeag & Jeffrey S. Kutcher, *Concussion Consensus: Raising the Bar and Filling in the Gaps*, 19 CLINICAL J. SPORT MED. 343, 344–45 (2009) (noting that the variability of each brain poses a challenge to clinical decision making).

61. *Id.* at 343–45 (noting that even if you had 100 similar athletes sustain identical traumas to the head, the outcomes for each would be different because of individual variations in the brain).

62. *See* Adam Teitcher, Note, *Weaving Functional Brain Imaging Into the Tapestry of Evidence: A Case for Functional Neuroimaging in Federal Criminal Courts*, 80 FORDHAM L. REV. 355, 393–94 (2011) (noting that if neuroimaging were to be used, in this case, as evidence in a criminal trial, it would not be used in isolation to draw definitive conclusions, but it would still be considered in the context of other types of evidence).

63. *See* *DNA Fingerprinting*, GENEED, http://geneed.nlm.nih.gov/topic_subtopic.php?tid=37&sid=38 (last visited Mar. 29, 2015) (explaining how DNA fingerprinting—that is, DNA used in a forensic or criminal case context—is when DNA evidence is taken from a crime scene and compared to a sample from a suspect); *see also How Accurate is Forensic Analysis?*, WASH. POST (April 16, 2012), http://www.washingtonpost.com/wp-srv/special/local/forensic-analysis-methods/ (observing that DNA is the only method of forensic analysis that is consistent and accurate, though if lab technicians do not handle the DNA evidence properly, the accuracy could be compromised).

although not (quite) zero, infinitesimal.[64] Forensic laboratories could always make those odds even lower by examining more than the tiny fraction of DNA currently pressed into normal forensic use.[65]

But even forensic DNA is not, and cannot be, perfect.[66] Some people have twins, and forensic DNA, at least as it is usually employed today, cannot distinguish between identical twins, though it can easily distinguish non-identical ones.[67] Some DNA samples will be degraded or so intermingled as to lead to possible errors.[68] Some samples will be mislabeled or misread through accident or through fraud.[69]

The rest of genetics, that is, genetics that looks for associations between genetic variations and diseases or traits (and *not* identification of genetic variations and diseases or traits), provides a useful parallel. Some doctors and scientists used to think that genes were destiny—that a particular genetic variant led inevitably to a particular result.[70] The more we have learned about genetics, the less true that view has become.[71] In

64. *See* William C. Thompson et al., Ho*w the Probability of a False Positive Affects the Value of DNA Evidence*, 48 J. FORENSIC SCI. 1, 1 (2003) (citing to a an example of a jury being told that a random match, though unlikely, could occur).

65. *See* William C. Thompson, *The Potential for Error in Forensic DNA Testing (an Extract from the Full Paper)*, GENEWATCH, Nov.–Dec. 2008, at 5, 8 (noting that as the number of alleles in a DNA profile decrease, meaning that a smaller sample is compared, the probability that a random person would be a match for that sample increases, which suggests that the converse is also true).

66. *See id.* at 5–6 (describing how DNA matches are generally very reliable, but it cannot be guaranteed to be accurate in every situation).

67. Traditional forensic DNA could not distinguish between identical twins, but next generation sequencing technology will likely resolve this problem. *See* Jacqueline Weber-Lehmann et. al., *Finding the Needle in the Haystack: Differentiating "Identical" Twins in Paternity Testing and Forensics by Ultra-Deep Next Generation Sequencing*, 9 FORENSIC SCI. INT'L: GENETICS 42, 45 (2014) (describing new testing methods that would be able to distinguish identical twins because of very small genetic variations found in body fluid samples); *see also* Nadia Drake, *A Test That Distinguishes Identical Twins May Be Used in Court for First Time*, WIRED (Dec. 4, 2014) http://www.wired.com/2014/12/genetic-test-distinguishes-identical-twins-may-used-court-first-time/ (describing how this new technique could be used in the legal arena this year to solve a rape case where DNA evidence taken from semen will indicate that one man committed the crime—not his twin brother).

68. *See* Thompson, *supra* note 65, at 6 (describing how degradation or contamination can interfere with accurate matching in DNA samples).

69. *Id.* And, of course, even a correct DNA identification only says the sample came from the suspect or defendant, not that he was guilty of the crime. The DNA may have gotten to the crime scene innocently. *See id.* (discussing potential errors in the laboratory setting and the possibility that someone could intentionally manipulate the biological evidence).

70. *See* I. de Melo-Martín, *Firing up the Nature/Nurture Controversy: Bioethics and Genetic Determinism*, 31 J. MED. ETHICS 526, 526 (2005) (stating that discussions of genetic determinism have been around for a long time).

71. *See* Margaret Lock, *Eclipse of the Gene and the Return of Divination,* 46 CURRENT ANTHROPOLOGY (SUPP.) S46, S50 (2005) (explaining that genes determine very little).

defense of those who supported this theory, the first associations between particular genetic variations and diseases were always very strong. The strongest associations were the easiest to find and hence the first to be found, leading to ascertainment bias. It was not irrational to think that other, still undiscovered single genetic variations would also be fully responsible for diseases. Instead, for most diseases (including some, like cystic fibrosis, which used to be thought as "fully penetrant," affecting everyone with the relevant genetic variation), we now know that variations in DNA are almost always just one influence, increasing or decreasing the person's risk from that of the average person, along with the effects of environment and chance.[72] Genetic variations are thumbs on the probability scale, moving people from, for example, a 15 percent lifetime risk of a disease up to a 25 percent risk, or down to a five percent risk.

There are still some variations in the genome that are all powerful. As far as we know, the only way a person with the genetic variations that cause Huntington's disease will not die from that disease is to die first from something else.[73] There may be a few cases where neuroimaging evidence will be similarly powerful. It seems likely, for example, that an adult[74] whose visual cortex is shown (by neuroimaging) to have been completely destroyed by a tumor, a stroke, or an accident will be totally blind.[75] Without a visual cortex, even someone with perfectly functioning eyes and nerves will not be able see.[76]

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72. *See* Steven P. Spielberg, *Editor-in-Chief's Commentary: Gene Penetrance, Therapeutic Targets, and Regulatory Science*, 47 THERAPEUTIC INNOVATION & REG. SCI. 289, 289 (2013) (explaining that cystic fibrosis is now understood to be caused by a variety of mutations); *see also* Lock, *supra* note 71, at S50 (characterizing genes as one actor in a complex scenario).

73. *See* Marianne J U Novak & Sarah J Tabrizi, *Huntington's Disease*, 341 BRIT. MED. J. 34, 37 (2010) (labeling Huntington's as a slowly progressing incurable disease).

74. Brains are complicated, and sometimes damage to seemingly essential areas can be compensated for if it happens early in life. For example, some children who are missing half of their cerebrums—the biggest and most "human" part of the brain—can grow up to be normal or very close to it. *See* Charles Choi, *Strange but True: When Half a Brain Is Better than a Whole One*, SCI. AM. (May 24, 2007), http://www.scientificamerican.com/article/strange-but-true-when-half-brain-better-than-whole (explaining the operation of hemispherectomy and how children receiving the operation develop with normal memory and personality).

75. *See* Marco Tamietto et al., *Unseen Facial and Bodily Expressions Trigger Fast Emotional Reactions*, 42 PROC. NAT'L ACAD. SCI. U.S. 17661, 17661 (2009) (referring to the phenomenal blindness that results from unilateral destruction of the visual cortex). *But see* Petra Stoerig, *Blindsight, Conscious Vision, and the Role of the Visual Cortex*, 155 PROGRESS BRAIN RES. 217, 230 (2006) (noting that the brain's plastic capacities allow functional improvements following the destruction of the primary visual cortex).

76. *See How Vision Works*, BRAIN HQ, http://www.brainhq.com/brain-resources/brain-facts-myths/how-vision-works (last visited Mar. 8, 2015) (explaining how the visual cortex is necessary for the perception of size, depth, edges, color, and form).

For mindreading, understanding a specific individual's subjective mental states means that it seems likely that most, if not all, of the neuroimaging evidence will be suggestive (or non-informative), but not conclusive. But it will still provide *some* evidence. How good that evidence will be and how we will want to use it are the questions to which we now turn.

II. HOW MIGHT THE LAW USE NEUROSCIENCE-BASED MINDREADING EVIDENCE?

Assuming the evidence were sufficiently accurate, an issue discussed in Part III, the possibilities for using neuroscience-based mindreading evidence in the law are limited only by the relevance of mental states to the law, which is to say, almost unlimited. This section will briefly set out three potential uses: communication, lie detection understood broadly, and lie detection understood narrowly.

A. Communication

Neuroimaging-based mindreading might allow communication with people with whom one cannot otherwise communicate. An amazing example of this comes from recent research in people who have "disorders of consciousness."[77]

These people have consciousness that is limited in one way or another.[78] Some are in comas, which is a relatively transitory state akin to

77. *See generally* Joseph T. Fins, *Rethinking Disorders of Consciousness: New Research and Its Implications*, 35 HASTINGS CENTER REP. 22, 22 (2005) (explaining how new understandings of brain injury are shaping how the potential for recovery is approached); *Disorders of Consciousness*, DRUGS.COM, http://www.drugs.com/cg/disorders-of-consciousness.html (last visited Mar. 15, 2015) (explaining disorders of consciousness as conditions where the state of awareness or wakefulness is disturbed); *see also* Matthew H. Davis et al., *Dissociating Speech Perception and Comprehension at Reduced Levels of Awareness*, 41 PROC. NAT'L ACAD. SCI. U.S. 16032 (2007) (finding high levels of resilience for speech during sedation); J. Andrew Billings et al., *Severe Brain Injury and the Subjective Life*, 40 HASTINGS CENTER REP. 17, 17 (2010) (referring to the novel idea that communication with patients may be possible following a severe brain injury); D.J. Wilkinson et al., *Functional Neuroimaging and Withdrawal of Life-Sustaining Treatment from Vegetative Patients*, 35 J. MED. ETHICS 508 (2009) (outlining the ethical issues associated with removal of life support in the context of new brain-imaging research).

78. *See* Olivia Gosseries et al., *Disorders of Consciousness: Coma, Vegetative and Minimally Conscious States*, *in* STATES OF CONSCIOUSNESS: EXPERIMENTAL INSIGHTS INTO MEDITATION, WAKING, SLEEP AND DREAMS 29, 30–31 (Dean Cvetkovic & Irena Cosic eds., 2011) (explaining that when the interaction of the cerebral cortex, brainstem, and thalamus is disrupted, consciousness becomes impaired).

deep sleep.[79] People in comas do not respond to stimuli; they tend either to die or improve within a few weeks.[80] Other people are in what is called a "vegetative state."[81] These people are also unresponsive to stimuli, but they do not always seem to be asleep.[82] They go through sleeping/waking cycles, and during the waking portions, their eyes will open, their bodies will move, and sounds will issue from their mouths; none of those actions is any apparent response to any stimuli.[83] Another group is classed as those in a "minimally conscious state."[84] These people usually appear to be vegetative, but occasionally—a few times a day, once every few weeks—have short periods of responsiveness.[85] People in a vegetative or minimally conscious state may be in those states permanently, may improve, or may decline.[86]

Two researchers, Adrian Owen, originally of Cambridge University and now at the University of West Ontario, and Steven Laureys at the University of Liège, have been exploring these states for over a decade.[87] A few years ago, they used 54 consecutive people who came into their hospitals in either a vegetative state or a minimally conscious state as research subjects.[88] They put these people in MRI scanners and talked to them.[89] They told each of these people two different things: either to think about playing tennis ("motor imagery"), or to think about walking through their homes or around their neighborhoods ("spatial imagery").[90]

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79. *See id.* at 32 ("Coma is a state of non-responsiveness in which the patients lie with closed eyes cannot be awakened even when intensively stimulated.").

80. *See id.* at 32–33 (explaining that people in comas have neither verbal production nor response to command, but can present reflexive responses to pain, and that prolonged comas progress to brain death, a vegetative state, or sometimes a locked-in syndrome).

81. *Id.* at 33; *see infra* note 82 (describing the awareness level of a vegetative patient).

82. *See* Gosseries et al., *supra* note 78, at 33 (explaining that the vegetative patient is awake but not aware).

83. *Id.*

84. *Id.* at 34; *see also infra* note 85 (describing the capacity for communication of the minimally conscious patient).

85. *See* Gosseries et al., *supra* note 78, at 34 (stating that patients in a vegetative state cannot functionally communicate, but can sometimes respond to verbal commands and make understandable verbalizations).

86. Martin M. Monti et al., *Willful Modulation of Brain Activity Disorders of Consciousness*, 362 NEW ENG. J. MED. 579, 580 (2010).

87. *Id.* at 579; *see generally* Steven Laureys et al., *Brain Function in Coma, Vegetative State, and Related Disorders*, 3 LANCET NEUROLOGY 537 (2004) (demonstrating the author's affiliation and credentials).

88. Monti et al., *supra* note 86.

89. *See id.* at 581 (describing what the researchers discussed with the patients).

90. *Id.*

While these conversations were going on with totally unresponsive subjects, the MRI was doing an fMRI scan, detecting relative ratios of oxygenated and de-oxygenated hemoglobin to determine what areas of the brain were active when the subjects were told these scenarios.[91] Specifically, for the tennis question, the researchers looked for activation in the secondary motor area, which is usually activated when people are thinking about making motions.[92] For the walking around question, the researchers were looking for activation in the parahippocampal gyrus, an area that is often activated when people are navigating.[93] For 49 of the 54 people, the researchers found no signal in either location.[94] For five people, the researchers got activation in the secondary motor area when they were talking about tennis; for four of those five people, and no one else, when they were asked the navigation question, the researchers saw activation in the parahippocampal gyrus.[95]

These people had not been responding outwardly, by any sign, to anything, but their brains responded to being talked to. That, in itself, does not mean they were conscious, as a sleeping person's brain might distinguish between hearing a siren in the distance and hearing a baby cry. Owen and Laureys took the experiment a step further.[96] One of their subjects had been diagnosed as in a persistent vegetative state for over five years.[97] He was one of the four people whose brain responded to both questions, so they put him back in the MRI scanner and asked him yes and no questions, such as "Was your father's name Alexander?" and "Do you have any brothers?"[98] The patient, although completely outwardly unresponsive, "was instructed to respond by thinking of one type of imagery (either motor imagery or spatial imagery) for an affirmative answer and the other type of imagery for a negative answer."[99] He was asked six

91. *Id.* at 579; *see generally* Jeroen C.W. Siero et al., *Blood Oxygenation Level-Dependent/Functional Magnetic Resonance Imaging: Underpinnings, Practice, and Perspectives*, 8 PET CLINICS. 579, 579 (2013) (providing a comprehensive overview of blood oxygenation level-dependent brain activity).

92. *See* Monti, *supra* note 86, at 579, 581 (explaining that imagery tasks are associated with MRI activity in certain portions of the brain, and disclosing why the researchers chose these types of questions).

93. *See id*. at 584 (noting that activity in the parahippocampal gyrus during the activation period was compared to the parahippocampal gyrus activity during the rest period).

94. *Id.* at 585, 588.

95. *Id.* at 583.

96. *See id.* at 585 (explaining that the researchers conducted additional tests on some participants).

97. *Id.* at 581.

98. *Id.*

99. *Id.*

questions, and based on the activation patterns in his fMRI scan, got the first five right.[100] For whatever reason—sleep, boredom, ambiguity, confusion, something else—he made no discernible response to the last question.[101]

Since that 2010 publication, this field has been very active and the story has become complicated, but no one seems to doubt that at least some people in vegetative states can use this method to respond correctly to some questions—that is, mindreading for communication.[102] You could imagine using that method for answers to be used in court, in a hospital, or in a nursing facility in order to ask people whether they are in pain, what treatment they want, or anything else. The legal and non-legal implications are profound.

B. Lie Detection Broadly

The biggest use of neuroscience-based mindreading in law will be de facto lie detection. This is not necessarily lie detection, where the mind is probed to see if it has a deceptive purpose, but looking for evidence of mental states that are at variance with the person's description of his or her mental state. Thus, when someone who answers the question "are you in pain?" with "yes, I am," testing for whether that person's physical brain state is or is not strongly correlated with the subjective mental state of pain is, in effect, lie detection.

This form of lie-detection is neither new nor unusual. Police officers could stop a driver whose car is weaving and ask, "Are you intoxicated?" When the driver slurs "off courshe I'm nawt, orfisher," the policeman could take the driver's word for it, or the policeman could test his blood alcohol using a Breathalyzer. In that case, the Breathalyzer functions, at least in part, as a lie detector.[103] It provides evidence of a mental state in addition to the person's self-report.[104] "Doping" tests in sports are another example. So

100. *Id.* at 584–85.

101. *Id.* at 585.

102. *See, e.g.*, Dalia B. Taylor, Note, *Communication with Vegetative State Patients: The Role of Neuroimaging in American Disability Law*, 66 STAN. L. REV. 1451, 1451 (2014) (providing an article showing that the field is expanding).

103. Looked at rigorously, a breathalyzer is both less and more than a lie detector. The drunk driver might honestly believe he is sober, so detecting a high blood alcohol might provide evidence of intoxication without necessarily showing that the driver lied. At the same time, the breathalyzer's blood alcohol percentage is correlated only imperfectly with the subjective mental state: two people could have the same blood alcohol percentage with very different subjective mental states.

104. *See supra* note 103 and accompanying text.

are law school exams—a professor could just ask her students, "do you understand the course really well? Well? Not so well? Terribly?" The professor could give them grades based on their answers to that question. In many areas, however, we are not comfortable relying on self-report and, when we can, we want more evidence than just someone's statement.

Neuroscience-based mindreading may be able provide additional evidence to double check a person's reported mental state wherever mental state is important to the law. Neuroscience-based pain detection is one clear example. It could be useful for people—infants or the unconscious—or even, perhaps, non-people (non-human animals or maybe human fetuses) who cannot communicate. But it is likely to be more useful in testing whether somebody who claims to be in pain is showing the brain activation patterns that do or do not correlate with the existence of either acute or chronic pain.

Pain is not the only such legally important mental state. My Stanford colleague Anthony Wagner studies the neuroscience of memory.[105] He did an experiment where he showed the research subjects (who were largely undergraduate psychology majors, probably second only to rodents as subjects of fMRI experiments) photographs of 476 faces, giving them a few minutes to look at them, and telling them to try to remember the faces.[106] He then put the subjects in an MRI and showed them 150 faces, half that were among the faces they had seen before and half that were not.[107] He told them to push one of two buttons to signal whether they had or had not seen the faces before.[108] When he analyzed the fMRI results, he was able to predict which button they were going to push; in other words, he was able to determine whether they *thought* they recognized the face or not.[109] He was much less able to predict whether they had actually seen the face, though he was still statistically significantly better than chance.[110]

Is that important? Well, think about a test where you show a defendant in an MRI pictures of unpublicized pictures of a crime scene and then

105. *See generally* Kolber, *supra* note 15, at 439 (describing how neuroimaging may supplement our evaluations of pain); Jesse Rissman et al., *Detecting Individual Memories Through the Neural Decoding of Memory States and Past Experience*, 107 PROC. NAT'L ACAD. SCI. U.S.A. 9849, 9849–50 (2010) (describing a study in which participants were exposed to grayscale photographs of faces).

106. Rissman et al., *supra* note 105, at 671–72.

107. *Id.* at 673 (describing the data acquisition process in which the functional imaging was performed on a 3-T Signa MRI system and subjects were then exposed to the images).

108. *Id.* (noting that all participants responded using a keypad).

109. *See generally id.* at 678 (explaining the novelty detection and prediction error).

110. *See id.* at 678–79 (explaining how there was enhanced activation versus face stimuli during the probe period).

examine the results to determine whether his brain, right or wrongly, recognized them or not. That should certainly not be used as conclusive evidence of guilt or innocence, but it might be some evidence at trial and, perhaps more importantly, before trial in making decisions about whom to investigate.

A similar technique uses EEG, electro-encephalography, which has many advantages over fMRI—it is cheap, portable, and easy to operate.[111] This method looks for something called the P300 signal, which is a response that occurs about 300 milliseconds after some stimuli.[112] Researchers are not sure whether it comes after stimuli that subjects remember or recognize, or if the response merely seems salient—if it occurs only after they see something that draws their attention.[113] This use of the P300 signal has had, in some scientific circles, a bad name.[114] The first researcher to push this enthusiastically was Dr. Larry Farwell, who formed a company called "Brain Fingerprinting" to use P300 for lie detection, and then promoted it in ways that most people in the field thought were exaggerated, putting the whole approach under a cloud.[115] Another researcher, Professor Peter Rosenfeld at Northwestern, has also worked very hard on this approach along with many other researchers around the world.[116]

Rosenfeld, again using undergraduate subjects, showed each subject three photographs related to a terrorism scenario.[117] He showed them an iconic picture of a city (the Golden Gate Bridge for San Francisco, for example), a location (a sports arena, an office building, or a school), and a

111. *See* Fabio Massimo Zanzotto & Danilo Croce, *Comparing EEG/ERP-Like and fMRI-Like Techniques for Reading Machine Thoughts*, 6334 BRAIN INFORMATICS 133, 134 (2010) (explaining how ERP/EEG is a relatively cheaper technique that provides more course-grained data as opposed to fMRI models).

112. *See* Vahid Abootalebi et al., *A comparison of Methods for ERP Assessment in a P300-Based GKT*, 62 INT'L J. PSYCHOPHYSIOLOGY 309, 310 (2006) (explaining how the peak is between 300–1000 ms from the stimulus onset).

113. *Id.* (noting that the efficacy of P300-based lie detectors is still controversial).

114. *See generally* J. Peter Rosenfeld, *Brain Fingerprinting: A Critical Analysis*, 4 SCI. REV. MENTAL HEALTH PRAC. 20, 21 (2005) (explaining how even though there has been considerable positive publicity, there has also been negative criticism, and that the P300 has not been necessarily a successful lie detector).

115. *Id.*at 20.

116. *See id.* (acknowledging that Rosenfeld is one of many investigators who have used brain waves and related technology in the detection of deception).

117. *See* John B. Meixner & J. Peter Rosenfeld, *A Mock Terrorism Application of the P300-Based Concealed Information Test*, 48 PSYCHOPHYSIOLOGY 149, 150 (2010) (explaining the participants selected and the use of three different categories of information used in the study).

potential weapon (a bomb, a propane tank, or an automatic rifle).[118] Each subject saw one photo from each category, recreating in a sense, the board game Clue: a propane tank, in San Francisco, in a football stadium.[119] He then showed them all the pictures in random order while they were being monitored by the EEG, and looked for their P300 reactions.[120] He reported that with over 90 percent accuracy, he could tell from their reactions which photos that the particular subject had seen earlier.[121] This is not "lie detection" since the subjects had not lied or even said anything. But if the subjects had been asked about a terrorist plot, this would be one way of providing some evidence about the accuracy of what they answered.

C. Lie Detection Narrowly

In addition to these indirect methods of de facto lie detection, there is frank lie detection, where people claim to be looking for signals of deception itself.[122] This has received a great deal attention (including from me), mainly because two companies started selling this lie detection service in the United States in 2007.[123] Only one company is still in the market (the improbably named No Lie MRI), while its competitor (the more restrained "Cephos") has dropped this service.[124]

Over 30 peer-reviewed studies have now found statistically significant correlations between patterns of brain activation and when somebody is

118. *Id.* (explaining the procedure in which subjects were presented with a location, date, and method of a planned attack).

119. *Id.* (describing the random order of each category).

120. *Id.* at 151 (describing the data acquisition process and how the bootstrap method was applied in order to evaluate P300 reactions).

121. *Id.* at 152 (positively identifying 12 out of 12 "hypothetical" terrorism suspects through the use of P300 mindreading).

122. *See generally* Greely & Illes, *supra* note 19, at 377 (summarizing twelve research studies which measured brain signals to identify deception signals in the brain); Elena Rusconi & Timothy Mitchener-Nissen, *Prospects of Functional Magnetic Resonance Imaging as Lie Detector*, 7 FRONTIERS HUMAN NEUROSCIENCE 1 (2013) (analyzing scientific and legal challenges to the use of fMRI scans as lie detectors, and concluding that due to ethical, operational, and social hurdles, current fMRI procedures are unlikely to constitute a viable lie detector for criminal courts).

123. *See* Rusconi & Mitchener-Nissen, *supra* note 122, at 4 (noting that No Lie MRI and Cephos Corporation were founded in 2006 to bring lie detection tests to the court room).

124. *See id.* (describing private companies who conduct fMRI lie detection); *see also* Greg Miller, *Neuroscience is Getting Its Day in Court, Whether It's Ready or Not*, WIRED (Dec. 16, 2013, 6:30 AM), http://www.wired.com/2013/12/brain-science-law/ (confirming that Cephos no longer provides fMRI lie-detection services).

lying.[125] The biggest concern with these findings though (apart from the fact that the studies did not all find the *same* patterns of activation) is their lack of "ecological realism."[126] The experiments were usually done with undergraduates, and were always done with people who knew they were in an experiment and were following orders to "lie."[127] But how relevant are their reactions to a situation where someone under arrest says "no, I didn't try to buy cocaine from that officer"? This kind of method to detect a brain signal of deceptive intent might turn out to work at some point, but much more work needs to be done before it can reliably be used.

Judicial tests exist to determine whether scientific evidence like this can be admitted in court, but there are many places within the legal system (in criminal investigation and in sentencing, for example) where those constraints do not apply.[128] And there are almost no constraints on selling these kinds of mind-reading services outside the legal system.[129]

III. HOW TO JUDGE NEUROSCIENCE-BASED MINDREADING

If our society wants to use neuroscience-based mindreading, it is easy enough to do it poorly. The better question is, how can we do it well? What kind of proof should we demand before we accept such procedures as providing reliable and useful evidence either inside or outside the courtroom? The answer boils down to two things: science and systems. We need to be confident that the science can provide powerful results, and we need to be confident in the systems we use to produce those results. This

125. *See* Uri Hasson & Christopher J. Honey, *Future Trends in Neuroimaging: Neural Processes as Expressed Within Real-life Contexts*, 62 NEUROIMAGE 1272, 1273 (2012) (noting the growth of fMRI papers since 1994); *see also, e.g.*, G. Ganis et al., *Neural Correlates of Different Types of Deception: An fMRI Investigation*, 13 CEREBRAL CORTEX 830–36 (2003) (finding that lies elicited more brain activation than telling the truth).

126. *See infra* note 127 and accompanying text; *see also* Greely & Illes, *supra* note 19, at 403–04 (detailing that one of the main criticisms of the research is that study participants are not being observed in real-world circumstances, and that they lie about something unimportant or "under command").

127. Greely & Illes, *supra* note 19, at 403–04 (noting another criticism of the research is that they "used healthy young adults, almost all right handed, with little gender or ethnic diversity"); *see, e.g.*, Meixner & Rosenfeld, *supra* note 117, at 152 (participants were undergraduate students at Northwestern University).

128. *See generally* Pamela J. Jensen, Note, *Frye Versus* Daubert*: Practically the Same?*, 87 MINN. L. REV. 1579–1620 (2003) (analyzing the two general standards, *Frye* and *Daubert*, for determining the admissibility of novel scientific expert testimony).

129. *See generally* Amy E. White, *The Lie of fMRI: An Examination of the Ethics of a Market in Lie Detection Using Functional Magnetic Resonance Imaging*, 22 HEALTHCARE ETHICS COMMITTEE FORUM 253, 259–61 (2010) (analogizing the use of fMRI to that of a polygraph test in analyzing the ethical and legal considerations when using fMRI testing).

section will explore both of those points, and will then suggest, as an example, how we might seek to make neuroscience-based pain detection reliable enough for widespread use.

A. Science

Neuroscience-based mindreading depends on correlating subjective mental states with physical brain states using fMRI, with activation patterns inferred from ratios of oxygenated to de-oxygenated hemoglobin.[130] We will need good science to know just how strong those correlations are. Science would benefit from five things that are generally missing today: big samples, diverse samples, ecologically realistic experiments, studies of countermeasures, and, of at least some value, underlying theories to help explain (and test) the correlations.

Most fMRI experiments today are done with only a few subjects, whether that be four, ten, twenty, or thirty. Although the published studies claim statistical significance in spite of the low numbers, we would be more confident if we had studies done on hundreds or thousands of people. The problem is that fMRI studies are expensive—one hour-long scan of one subject, when overhead and analysis costs are included, will often cost a researcher more than $1,000.[131] Genetics projects can get multi-million dollar grants; fMRI research has to make do with much smaller budgets and hence, much smaller numbers.[132]

But just having more subjects is not enough. Testing 10,000 white, right-handed undergraduate males at elite schools, all of whom denied ever taking illegal drugs, would not necessarily tell us about people who did not meet those criteria. For confidence, good-sized studies need to be done on young people and old people, men and women, people who have taken drugs and those who haven't, people who are currently taking drugs and people who aren't, people who have had mental illnesses of various sorts

130. *See* Rusconi & Mitchener-Nissen, *supra* note 122, at 2.

131. *See* Yale School of Medicine, *Usage Charges*, MAGNETIC RESONANCE RES. CENTER, http://mrrc.yale.edu/users/charges.aspx (last visited Mar. 2, 2015) (quoting a $720 cost per fMRI slot plus a $250 per study for analysis support).

132. *See, e.g.*, U.S. Dep't of Health & Human Services, *Estimates of Funding for Various Research, Condition, and Disease Categories (RCDC)*, NIH RES. PORTFOLIO ONLINE REPORTING TOOLS (Feb. 5, 2015), http://report.nih.gov/categorical_spending.aspx (providing a list of every grant awarded by the NIH in the past three years, detailing that research dollars granted to all "Neurosciences"—including fMRI research—totaled about $5.7 billion compared with $7.5 billion granted to "Genetics" research).

and people who haven't.[133] Fundamentally, one would like to have good studies of a wide variety of people who are, in most (if not all) plausibly relevant ways, like the real life subject who would be questioned using mindreading.

At the same time, the experiments need to be realistic. In some cases, that may not be hard. For people who claim to have incapacitating back pain while lying down, having them lie down in scanners will be fairly similar to their real world experience—that is, assuming they are not so distracted or frightened by the scanner as to produce different results. Other cases may be more difficult, sometimes for physical or temporal reasons. People whose back pain comes when sitting may not be easily testable in the horizontal tubes of most MRI machines. People who claim occasionally to experience crippling headaches just may not have a headache when scanned.

Sometimes, though, the problems will not be physical or logistical, but ethical. Lie detection experiments today are done on people who know they are in a research experiment, who have signed a consent form after being told about the experiment, who are following orders to lie, and who face no severe consequences if their lie is not believed.[134] A much better test would be to have the police arrest some random undergraduates for, say, underage drinking offenses and scan them all when they are questioned about their drinking. A blood test or a Breathalyzer should be able to provide a "gold standard" for whether they had been drinking; those questioned could be divided into a two-by-two matrix of those who had been drinking and those who hadn't, and those who had told the truth and those who didn't.

The only problem is that no institutional review board ("IRB") will (or should) allow you to treat research subjects that way. Yet, without the spur of real anxiety leading to "real" lying, it may not be possible to know whether the mindreading techniques from controlled experiments would produce the same result with real criminals, or even with the dutiful son who, less than truthfully, says on Thanksgiving, "no, Mom, the turkey was perfect and it wasn't too dry." The results in a typical experiment might transfer to the real world, but they might not. Without some more realistic experiments, how can we be confident about their relevance?

Countermeasures raise another important issue. Consider neuroimaging for pain detection. Many people who have had kidney stones

133. *See generally* Katherine S. Button et al., *Power Failure: Why Small Sample Size Undermines the Reliability of Neuroscience*, 14 NATURE REVS. NEUROSCIENCE 365, 365–66 (2013) (analyzing how the incentive to publish causes scientists to limit the sample size, thus reducing the reliability of their studies).

134. *See* Greely & Illes, *supra* note 19, at 403–04.

will be happy to tell you how painful they were. If a plaintiff is in an MRI machine trying to pretend that he is feeling pain, what will the scanner show if he concentrates on remembering every excruciating detail of his kidney stone? We don't know. We know that countermeasure can be successfully employed (by at least some people) against the polygraph, but most mindreading researchers (with a few honorable exceptions) have not begun to think about seeing if countermeasures work, or if there are countermeasures to the countermeasures.[135]

For all of these points, it would help if neuroscience had provided strong predictive theories about what kinds of brain activation patterns one *should* expect for certain subjective mental states. A set of testable hypotheses, if consistently upheld in experiments, could give us more confidence that the correlations we are seeing are real. Right now, most of this work is purely empirical—subjects in scanners are exposed to stimuli that are expected to create a subjective mental state (pain, recognition, deception), and the researchers trawl through the universe of the fMRI data looking to see what seems to be associated with the stimulus.[136] Compare that to forensic DNA, where we have excellent reasons (both theoretical and empirical) to believe that, apart from monozygotic (identical) twins, two people are extremely unlikely to have matching DNA profiles.[137]

More studies, with more diverse populations, with greater realism and attention to possible countermeasures, as well as some testable predictive theories about what kinds of activation patterns should be expected, would produce much greater confidence in the results of neuroscience-based mindreading. But science alone is not enough.

B. Systems

The second thing that is crucial to confidence in a scientific technology is a system. The tests should follow defined protocols, and should use accredited laboratories where the technicians follow the instructions in a manual to perform the test the same way every time.

135. *See generally* Giorgio Ganis et al,, *Lying in the Scanner: Covert Countermeasures Disrupt Deception Detection by Functional Magnetic Resonance Imaging*, 55 NEUROIMAGE 312 (2011) (examining the effects of countermeasures on the reliability of fMRI results).

136. *See* Rusconi & Mitchener-Nissen, *supra* note 122, at 2–3 (noting how the research aggregates data taken from brain scanners).

137. *See generally* Michael J. Saks & Jonathan J. Koehler, *What DNA "Fingerprinting" Can Teach the Law About the Rest of Forensic Science*, 13 CARDOZO L. REV. 361 (1991) (analyzing how the rigor of DNA testing provides a model for the introduction of new forms of forensic evidence); *see also* Rana Saad, *Discovery, Development, and Current Applications of DNA Identity Testing*, 18 BUMC PROC. 130 (2005) (describing the reliability of DNA testing).

Only one U.S. appellate decision has ruled on neuroscience-based lie detection: *United States v. Semrau*.[138] The district court magistrate judge (now an Article III district judge) wrote an excellent opinion, which the Sixth Circuit affirmed and largely adopted.[139] The Sixth Circuit took concern with the fact that the fMRI lie detection service (which the criminal defendant had used) made up their procedures as they went along.[140] The experiments on which they based their method had, unusually, been done on people aged 18 to 50, but the defendant was 63 years old.[141] They tested the defendant twice on the same day.[142] In the morning session, the result said he was telling the truth, but the afternoon session showed he was lying.[143] The firm then decided that he had probably been tired in the afternoon, so they repeated the test on a later day, getting another favorable result, which led the expert to testify that "a finding such as this is 100% accurate in determining truthfulness from a truthful person."[144]

Given that this particular person had "passed" the test only two times out of three, that "100%" seemed questionable, and that kind of ad hoc cherry picking of results does not promote confidence.[145] As the district court said:

> Because the use of fMRI-based lie detection is still in its early stages of development, standards controlling the real-life application have not yet been established. Without such standards, a court cannot adequately evaluate the reliability of a particular lie detection examination. Assuming, arguendo, that the standards testified to by Dr. Laken could

138. 693 F.3d 510 (6th Cir. 2012).

139. United States v. Semrau, No. 07-10074, 2010 U.S. Dist. WL 6845092, at *1 (W.D. Tenn. June 1, 2010), *aff'd*, 693 F.3d 510 (6th Cir. 2012).

140. 693 F.3d at 522 (noting that there are no concrete standards from real world testing, and that the tests that were performed on Dr. Semrau in the laboratory were different from those used in other studies, suggesting that the firm was still trying to understand the basics of fMRI lie detection results).

141. *Id.*

142. *Id.* at 518–19.

143. *Id.* at 519.

144. *Id.*

145. *Id.* at 519–20 (explaining that some doubt the results because there is a difference in what a person believes and conveys during the test, and what the person was thinking during the actual event).

> satisfy Daubert, it appears that Dr. Laken violated his own protocols when he re-scanned Dr. Semrau. . . .[146]

An excellent precedent exists for providing (and following) standards for forensic tests: forensic use of DNA.[147] The forensic use of DNA is not perfect—mistakes can be made, or test results can be corrupted intentionally.[148] But, overall, it has been remarkably successful.[149]

In the early 1990s, though, when prosecutors first tried to introduce DNA evidence in U.S. courts, it was very controversial.[150] One problem was with the science.[151] Experts disagreed about the likely effects of patterns of genetic variations within populations that might throw off the results.[152] Some argued that results based on the frequencies of different markers in, say, European-Americans might not apply to African-Americans or Native Americans.[153] These arguments resulted in a report by the National Academy of Sciences that concluded the concern was appropriate.[154] The report argued that further research needed to be done, but until it was, the courts should only allow the use of very conservative estimates of the odds against an accidental match.[155] Several years later, after that further research had been, the National Academy did a second

146. United States v. Semrau, No. 07-10074, 2010 U.S. Dist. WL 6845092, at *13 (W.D. Tenn. June 1, 2010), *aff'd*, 693 F.3d 510 (6th Cir. 2012) (citing United States v. Cordoba, 194 F.3d 1053, 1061 (9th Cir. Cal. 1999)).

147. Henry T. Greely et al., *Family Ties: The Use of DNA Offender Databases to Catch Offenders' Kin*, 34 J.L. MED. & ETHICS 248, 250 (2006) (noting that there is a uniform standard of DNA markers).

148. *See* NAT'L ACAD. OF SCIENCES, STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD 130 (1992) [hereinafter *Strengthening Forensic Science*] (noting that there is a possibility of false positives or fraudulent dealings with the results).

149. *Id.* at 184 (referring to the success that the judiciary system has had in the use of forensic DNA).

150. *See id.* at 40 (noting that there were concerns that there needed to be more blind trials prior to its use).

151. *See id.* at 40–41 (stating that the use of DNA evidence in the courts for forensic purposes was concerning due to the possibility of contamination and degradation of the evidence along with statistical analysis faultiness).

152. *See* Greely et al., *supra* note 147, at 251 (noting that certain genetic structures may cause random matches to be a greater possibility); *see also* NAT'L ACAD. OF SCIENCES, DNA TECHNOLOGY IN FORENSIC EVIDENCE 79–80 (1992) [hereinafter *DNA Technology*] (noting that population substructures could have an impact on genotype frequency calculations).

153. *See DNA Technology*, *supra* note 152, at 79 (stating that different allele frequencies are apparent in their respective racial groups).

154. NAT'L ACAD. OF SCIENCES, THE EVALUATION OF FORENSIC DNA EVIDENCE 187 (1996) [hereinafter *Evaluation of DNA Evidence*] (noting that the 1992 National Academy of Sciences report shows that there were differing views of population geneticists on this topic, which was "proof of a major scientific disagreement.").

155. *Id.* at 187 n.69, 204.

report and concluded the problem had been solved.[156] That is an example of the raising and answering of scientific questions about the technique.

At least as important for the use of forensic DNA was the standardization of testing protocols. In an early criminal case that involved the use of forensic DNA in the New York state courts, *People v. Castro*, after the day's testimony, some of the expert witnesses for the opposing sides got together and talked about the case. (I have heard one participant say that their discussions took place at a bar after the day's testimony.) Two of the prosecution experts agreed with the defense experts that the testimony should not be admitted because of the ways it did not live up to the standards under which such testing *should* be done.[157] Eventually, the Federal Bureau of Investigation ("FBI") started accrediting crime labs to do DNA work.[158] The FBI produces and regularly updates a manual that not only describes how the testing should be done, but states how and how often the laboratory should be audited.[159] Additional guidelines have been created by the National DNA Index System (CODIS) in its Standards for the Acceptance of DNA Data, and by the American Society of Crime Laboratory Directors Laboratory Accreditation Board.[160] The FBI and CODIS guidelines apply to forensic DNA analyses that the federal government conducts; the CODIS guidelines apply to testing done by the

156. *See* EDWARD CONNORS ET AL., NAT'L INST. OF JUSTICE, CONVICTED BY JURIES, EXONERATED BY SCIENCE: CASE STUDIES IN THE USE OF DNA EVIDENCE TO ESTABLISH INNOCENCE AFTER TRIAL 6 (1996) ("The state of the profiling technology and the methods for estimating frequencies and related statistics have progressed to the point where the admissibility of properly collected and analyzed DNA data should not be in doubt." (internal quotation marks omitted) (citation omitted)).

157. *See* William C. Thompson, *Evaluating the Admissibility of New Genetic Identification Tests: Lessons from the DNA War*, 84 J. CRIM L. & CRIMINOLOGY 22, 43 (1993); *see also* People v. Castro 545 N.Y.S.2d 985, 986 (N.Y. Sup. Ct. 1989) (noting that this constituted a landmark case for the admissibility of DNA evidence in criminal cases).

158. NATHAN JAMES, CONG. RESEARCH SERV., R41800, DNA TESTING IN CRIMINAL JUSTICE: BACKGROUND, CURRENT LAW, GRANTS, AND ISSUES 2 (2012).

159. QUALITY ASSURANCE STANDARDS FOR FORENSIC DNA TESTING LABORATORIES (2009), *available at* http://www.fbi.gov/about-us/lab/biometric-analysis/codis/qas_testlab.pdf; *see also Scientific Working Group on DNA Analysis Methods (SWGDAM)*, SWGDAM, http://www.swgdam.org/ (last visited Mar. 5, 2015) (noting that the Scientific Working Group on DNA Analysis Methods ("SWGDAM") works with the FBI to create guidelines and standards for DNA testing, analysis, and forensic work).

160. *See* Mark Nelson, *Making Sense of DNA Backlogs—Myths vs. Reality*, 266 NAT'L INST. JUST. J. 20, 23 (2010) (noting that CODIS was created as a DNA database, which is accessible to various federal and state agencies in their efforts to solve crime); *see also* FBI LAB., NAT'L DNA INDEX SYSTEM (NDIS) OPERATIONAL PROCEDURES MANUAL 5–6 (2013) (explaining the standards of acceptance of DNA data); *see also Objectives*, AM. SOC'Y CRIME LABORATORY DIRECTORS, http://www.ascld-lab.org/objectives/ (last visited Mar. 5, 2015) (noting that one of the objectives of the American Society of Crime Laboratory Directors Laboratory Accreditation Board is to establish testing standards and guidelines to improve forensic analysis).

states, but that is sent to the national CODIS registry.[161] For forensic DNA analysis that is only for state use, the states set their own standards, which usually adopt the FBI standards, the Accreditation Board's standards, or both.[162] These required procedures are, of course, to some extent bureaucratic and mindless, and they cannot prevent the occasional bad mistake or corrupt worker. They do, however, make the process more reliable and give judges and jurors (and the prosecution and defense counsel) more confidence in its result.

C. What Might Be Done and How: Pain Detection as an Example

Neuroscience-based pain detection could be tested to see how reliable it is by first starting with experiments that have lots of subjects with diverse characteristics, and by making the experimental conditions as similar as possible to the conditions experienced by people with legal claims stemming from pain. If some of the methods seem effective, test them for countermeasures and, if countermeasures seem effective, look for ways to detect or block them. And, while all of that testing is going on, researchers can do supportive research (and thinking) on testable theories for how the subjective feeling of pain *should* look in fMRI scans and why.

This is a process that is far beyond the possibilities of one researcher with an NIH grant. Ultimately, it could require tens of thousands of subjects and hundreds of millions of dollars. But one could ease into it. A researcher could start with one or more of the most common kinds of pain that arise in legal proceedings, at least as long as it seemed tractable to neuroscience-based detection. For example, a researcher could start by studying chronic and allegedly disabling lower back pain among people over, say, 50. It is a very common condition with an affected population that, although large, might be fairly carefully defined.[163]

161. *See* Nelson, *supra* note 160 (noting that both the federal and state level enforcement authorities have access to CODIS for DNA analysis information).

162. *See History of DNA Databases*, GOVERNOR'S OFF. CRIME CONTROL & PREVENTION, http://www.goccp.maryland.gov/dna/database.php (last visited Mar. 5, 2015) (noting that every state in the nation has a statutory provision for the establishment of a DNA database); *see, e.g.*, 44 PA. CONS. STAT. § 23 (2004) (providing for DNA detection of sexual and other offenders); *see also Frequently Asked Questions (FAQs) on the CODIS Program and the National DNA Index System*, FBI, http://www.fbi.gov/about-us/lab/biometric-analysis/codis/codis-and-ndis-fact-sheet (last visited Mar. 5, 2015) (noting that the CODIS and NDIS system are used both by both federal and state agencies in DNA analysis work).

163. *See Low Back Pain in Older Adults*, SPINE-HEALTH, http://www.spine-health.com/conditions/lower-back-pain/low-back-pain-older-adults (last visited Mar. 5, 2015) (explaining that individuals over the age of 60 frequently suffer from back pain). Note that there will still be a problem of having a "gold standard" baseline determination of whether a subject

Scans of one thousand subjects of different ages, sexes, ethnic backgrounds, drug use, and mental illness histories might be able to provide some solid statistical evidence (with confidence intervals) for how often the test produces false positives (in effect, its specificity) or false negatives (its sensitivity). From that, one could calculate its positive predictive value (what percentage of the time a positive test result will mean that someone is actually in pain), and its negative predictive value (what percentage of the time a negative test result will mean that someone is actually *not* in pain). These could be further refined depending on the strength or weakness of more traditional evidence about pain in particular cases. For example, in cases where the traditional measures strongly indicated that pain was present, the accuracy might be 98 percent; for weaker traditional evidence, the accuracy might fall to 80 percent. Then, for test methods where the results were promising, one hundred or two hundred subjects could be used to test potential countermeasures.

The experimental conditions that produced the best results could then be "routinized" for use in commercial laboratories or clinics. Expert groups could propose procedures, manuals, and accreditation procedures, and the accuracy rates of this pain detection in the "real world" could be tested using those approved methods.

At that point, if the results were favorable, we would have a pain detection test for a very common source of pain-related litigation for which we knew the accuracy, the confidence intervals, and the efficacy of countermeasures when these tests are performed according to standardized procedures. That does not mean the method would be adopted universally, if adopted at all. One issue lingers though: how good is good enough? Is a 98 percent positive predictive value (where only two percent of the subjects with positive tests actually do not feel pain) good enough? What about a 90 percent negative predictive value (where ten percent of those who test negative actually have pain)? Is the standard considered to be "good enough" for research purposes still "good enough" in a jury trial involving an automobile accident or in a social security disability proceeding before an administrative law judge? How would juries or judges be expected to weigh the neuroscience evidence against other, more traditional evidence about pain? But at the very least, we would have a test whose accuracy was well understood, and a test that people have reasons based on good evidence to accept or to reject.

"really" is or is not in pain. Clinicians may be able to identify clear cases in one direction or another, though that might still leave an intermediate group for whom the experimental results would not be as clear.

This would not be cheap though. My back-of-the-envelope estimate is that $15 to $20 million over three years might be enough to get a good handle on one or more tests for common chronic lower back pain. That is probably about 0.05 percent or less of the NIH budget, but the NIH does not include a "National Institute of Pain."[164] And this amount is a much higher percentage of the budget of the National Institute of Justice, which spends very little of its (very little) money on neuroscience research.[165]

But there should be ways to raise money for this kind of program of test development. Legal disputes over pain are common and costly.[166] We know that, even with present expert testimony, sometimes the results are wrong.[167] People who should win, lose; and people who should lose, win. Having a better test improves those results, which is a good thing, whether it leads to more money being paid out (but with more accuracy) or less money being paid out (also with more accuracy). There is another advantage: having a better test should prevent more pain cases from going to trial or going to hearings. The stronger the test, the more often lawyers or parties will settle, thus saving valuable resources that otherwise could all too easily be wasted in lengthy and expensive litigation.

The potential may be there, but who would do it? Insurers, state disability programs, or the Social Security Administration might finance such a research program; but if the research were only funded and supervised by potential defendants, plaintiffs, claimants, and the lawyers who represent them are likely to call foul. One would want to come up with a source (or sources) of funding that is perceived as neutral, or at least a source that is balanced in its biases toward each side. Finding such a source is a challenge. Unless we take that challenge and move toward a rational, well-funded program that seeks to create good neuroscience tests to detect pain, progress will be slowed—not so much by the lack of science, but by the lack of a plan and a program to get the science in a condition where it can be useful in resolving disputes.

164. *See* Consolidated and Further Continuing Appropriations Act, Pub. L. No. 113-235 (2015) (detailing the NIH budget for 2015); David Malakoff & Jeffrey Mervis, *First Look: New U.S. Spending Deal a Mixed Bag for Science*, SCIENCE INSIDER (Dec. 9, 2014, 10:30 PM), http://news.sciencemag.org/funding/2014/12/first-look-new-u-s-spending-deal-mixed-bag-science (explaining that the NIH is receiving roughly $30 billion for the fiscal year of 2015).

165. *See* Pub. L. No. 113-235 (describing the 2015 NIH budget).

166. Marc A. Franklin et al., *Accidents, Money, and the Law: A Study of the Economics of Personal Injury Litigation*, 61 COLUM. L. REV. 1, 2 (1961) (explaining that many people have experienced personal injury litigation, which is expensive).

167. *See* Douglas R. Richmond, *The Emerging Theory of Expert Witness Malpractice*, 22 CAP. U. L. REV. 693, 693–94 (1993) (noting that while courts have increasingly utilized expert witness testimony, expert witnesses have not always been accurate in their testimony).

IV. THE DEEPEST IMPLICATION

Let us say that, hypothetically, neuroscience-based mindreading works. Let us dream that someone neutral provides $20,000,000 over four years, and that the investment yields a test that detects the presence or absence of potentially disabling chronic lower back pain with positive and negative predictive values of about 90 percent, plus or minus three percent. If we are willing to accept 90 percent accuracy, especially when other sources of evidence may also be considered, are there still potential problems? Unfortunately, yes. Like all changes to the legal system, it will bring new issues in its wake, but one seems particularly profound. It is perhaps the deepest issue raised by mindreading.

Professor Nita Farahany has both written and is writing about an issue that she calls "cognitive liberty"—others think about it under the term "mental privacy".[168] Is scanning your brain different from a blood alcohol test? Is it different from watching how you walk or from listening to what you say? Is it invading something secret—or sacred?

I hate to use this example of my mother's Thanksgiving turkey, because my mother's Thanksgiving turkey is never too dry. But if by some odd chance one Thanksgiving, the turkey *were* too dry, and she were to ask me, as she always does, "the turkey's too dry this year, isn't it," then in the highly counterfactual case that it actually was too dry, I would, without hesitation or reservation, lie. If for some reason I could not lie, my ability at least to keep silent or otherwise sidestep the question would be very important.

In a more serious hypothetical, what if, for example, you are a citizen of the Democratic People's Republic of Korea. Assume the government puts you in a scanner and shows you pictures of Kim Jong Un (president of North Korea), then pictures of Park Geun-hye (president of South Korea), and then pictures of President Obama. If the government wanted to be able to "read" your brain's emotional reactions to each photograph, you might well want to be able keep your true feelings hidden.

Today we have that ability to hide, at least in practice. Although (at least when the Fifth Amendment's privilege against self-incrimination does

168. *See generally* Nita A. Farahany, *Incriminating Thoughts*, 64 STAN. L. REV. 351 (2012) (noting that individuals called to testify struggle with balancing the legal compulsion to testify with their own memories and personal thoughts, arguing that society should adopt more robust protections to safeguard cognitive liberties); *see also* Wrye Sententia, *Neuroethical Considerations: Cognitive Liberty and Converging Technologies for Improving Human Cognition*, 1013 ANNALS N.Y. ACAD. SCIENCES 221, 222–23 (defining cognitive liberty as "freedom of thought").

not apply) the law can "force you" to testify, and "force you" to tell the truth, it cannot really *force* you.[169] It can jail you for contempt if you refuse, and in some jurisdictions, it could torture you (or send you to allies who will do the torture somewhere else).[170] That may or may not get you to tell the truth—or merely get you to say whatever the torturers want to hear. Whatever the law, we have a special preserve that cannot reliably be invaded. If it could be invaded, should we allow it to? Should we say "never"? Or should we say, "it depends"?

If the mindreading is involuntary, it is tempting to say "no," but then one can construct "24 hour" terrorism scenarios that push the other direction, perhaps toward allowing some involuntary mindreading but only with a warrant.

There can also be "quasi-involuntary" circumstances. For example, say someone wants to bring a lawsuit alleging damages from pain, but the defendant seeks an order for a pain detection brain scan. The plaintiff may have a fundamental objection to having her mind read, but refusing a court-ordered medical test might lead to the dismissal of her suit. Is that mindreading "voluntary"?

Of course, society could only allow the use of this kind of mindreading on people who freely and genuinely volunteer. That seems fine—except if you allow one person to do it voluntarily, what will that imply about those who choose not to do it? Prosecutors might easily use this refusal against people who refuse: "Ladies and gentlemen of the jury, the defendant could have taken that lie detection test, but she chose not to. That is her right, but it is your right to draw whatever conclusions you want from her refusal." Federal law does not allow such an argument to be made in criminal cases where the defendant invoked the privilege against self-incrimination, but would such a prohibition apply in these cases, especially in state civil cases or administrative hearings? And would the decision maker draw the negative inference without hearing it argued? Allowing anybody to use neuroscience-based mindreading voluntarily puts pressure on everybody else to do it, and thus makes their decisions less voluntary.

Assuming we end up able to see through these scanners less darkly and more clearly, these are likely to be the deepest questions we will be forced to answer. If neuroscience-based mindreading becomes one of more useful

169. *See Being a Witness*, OHIO ST. B. ASS'N (April 10, 2014), https://www.ohiobar.org/ForPublic/Resources/LawFactsPamphlets/Pages/LawFactsPamphlet-20.aspx (explaining that while an individual may be compelled by the courts to testify, the individual does not physically have to testify).

170. *See id.* (explaining that if subpoenaed to be a witness in a trial, one must perform this duty or face contempt of court, which can result in jail time).

technologies, are there limits to when it should be used in order to protect cognitive liberty? If we do think there should be such a right, where do we find it—in the First, Third, Fourth, Fifth, Sixth, Seventh, and Eighth Amendments to the Constitution? And maybe in the Second, Ninth, and Tenth Amendments of the Constitution? Is it in a constitutional penumbra? Would we need new legislation, or would we need a new constitutional amendment? I leave these questions for another day, but I am confident that if neuroscience-based mindreading becomes feasible, as I suspect it will for at least some applications, the day for those questions will come.

CONCLUSION

Not only do we live in interesting times, we also live in times that are becoming more and more interesting, and much of the interest comes from "secondary uses." Neuroscientists are not (yet) receiving grants to create pain detectors for court purposes, or lie detectors for the criminal justice system.[171] In the United States, neuroscientists are mainly funded by the National Institutes of Health because we want to relieve human suffering by learning more about how the brain works and how we can affect it.[172] As we learn more about the brain, we will make valuable inroads against human suffering.

But, as we learn more about the brain, what we learn will not necessarily be limited to understanding, preventing, or treating diseases. Just as biological research could lead to biological warfare, more knowledge about neuroscience and how human brains work can lead to other applications of that knowledge for things like mindreading and other practices that have plusses and minuses very different from those of the health applications of the technologies.

We need, as a society, to pay enough attention, to become educated enough, and to think and worry enough about these secondary uses. Then, when they happen, we will have a decent chance to respond in an intelligent and useful way. I used to say that I do the work I do to try to maximize the benefits and minimize the harms of these new technologies. I have become

171. *See generally* Owen D. Jones & Francis X. Shen, *Law and Neuroscience in the United States*, *in* INTERNATIONAL NEUROLAW: A COMPARATIVE ANALYSIS 349, 350 (Tade Matthias Spranger ed., 2012) (noting the recent developments of neuroscience in the law and how various organizations are looking into funding neuroscientists so that they may develop more information on how neuroscience can benefit the law).

172. *See NIH Data Sharing Repositories*, TRANS-NIH BIOMED. INFORMATICS COORDINATING COMMITTEE (BMIC), http://www.nlm.nih.gov/NIHbmic/nih_data_sharing_repositories.html (last updated Mar. 10, 2015) (displaying NIH-supported data suppositories, including neuroscience research funded by NIH grants).

somewhat more humble. My hope now is that, if we can get enough people educated and thinking about these issues in advance, we may be able to avoid a few catastrophes.

So, I ask all of readers of this Article—please pay attention to the possible beneficial and less beneficial uses of neuroscience-based mindreading. If so, working together, we just might be able to avoid a few catastrophes.