Brain Scans as Evidence: Truths, Proofs, Lies, and Lessons

Francis X. Shen
Vanderbilt University – School of Law

Owen D. Jones
Vanderbilt University – School of Law & Department of Biological Sciences

[Forthcoming 62 Mercer L. Rev. (2011) (Symposium Issue: Brain Sciences in the Courtroom]

[Version of 01-22-2011; do not cite without permission]

BRAIN SCANS AS EVIDENCE: TRUTHS, PROOFS, LIES, AND LESSONS

Francis X. Shen [*] & Owen D. Jones [**]

[Version of 01-22-2011; do not cite without permission]
[Forthcoming 62 Mercer L. Rev. (2011)]

Abstract

This contribution to the *Brain Sciences in the Courtroom Symposium* identifies and discusses issues important to admissibility determinations when courts confront brain-scan evidence. Through the vehicle of the landmark 2010 federal criminal trial U.S. v. Semrau (which considered, for the first time, the admissibility of brain scans for lie detection purposes) this article highlights critical evidentiary issues involving: 1) experimental design; 2) ecological and external validity; 3) subject compliance with researcher instructions; 4) false positives; and 5) drawing inferences about individuals from group data. The article's lessons are broadly applicable to the new wave of neurolaw cases now being seen in U.S. courts.

INTRODUCTION

This *Brain Sciences in the Courtroom Symposium* is both timely and important. Given recently-developed and rapidly improving brain imaging techniques that enable non-invasive detection of brain activity, civil and criminal courts increasingly encounter attorneys proffering brain scans as evidence.[1]

[*] Visiting Scholar, Vanderbilt University Law School; Associate Director, MacArthur Foundation Law and Neuroscience Project.
[**] New York Alumni Chancellor's Chair in Law & Professor of Biological Sciences, Vanderbilt University; Director, MacArthur Foundation Law and Neuroscience Project.
This Article was prepared with the support of the John D. and Catherine T. MacArthur Foundation under Award No. 07-89249-000-HCD.
[1] For general introductions to law and neuroscience see: Oliver R. Goodenough & Micaela Tucker, *Law and Cognitive Neuroscience*, 6 ANNU. REV. LAW SOC. SCI. 28.1 (2010); Owen D. Jones, Joshua W. Buckholtz, Jeffrey D. Schall & Rene Marois, *Brain Imaging for Legal Thinkers: A Guide for the Perplexed*, 2009 STAN. TECH. L. REV. 5 (2009); Stacey Tovino, *Functional Neuroimaging and the Law: Trends and Directions for Future Scholarship*, 7 AM. J. OF BIOETHICS 44 (2007); Henry Greely & Anthony Wagner, *Reference Guide on Neuroscience, in* FEDERAL JUDICIAL CENTER REFERENCE MANUAL ON SCIENTIFIC EVIDENCE (3rd. Ed., forthcoming); STEPHEN J. MORSE & ADINA L. ROSKIES, EDS., *MACARTHUR PRIMER ON LAW & NEUROSCIENCE* (FORTHCOMING); OWEN D. JONES, JEFFREY D. SCHALL, & FRANCIS X. SHEN, *LAW AND THE BRAIN*

The reason is simple. In addition to caring about how people act (such as when they cause a person's death or sign a will), the legal system's inquiries frequently turn on determining what people were *thinking*, or were *capable* of thinking, when they acted.

In criminal law, for example, the same act can yield anything from mere probation to decades in prison, depending on what the legal fact-finders believe a defendant was probably thinking. And in the civil context, the beliefs held by a defendant about a particular risk are often central to a plaintiff's recovery. The unavoidable consequence is this: what that brain was actually doing at the time of an act, and indeed what a brain in court recollects about past acts, often matters a great deal to the administration of justice. And in all such cases, judges and jurors have it hard. It's simply not easy to read the mind of a stranger – or to assess with complete confidence either the subjective belief or objective accuracy of expressed recollections.

In all of human and legal history prior to just a few years ago, we have had to infer what was going on in a person's brain from a triangulation of circumstances, testimony, and projections of introspections. Against this historical backdrop, modern neuroscientific techniques seem to offer the tantalizing promise of informative, relevant, and high-tech cranial tours. Although it will rarely, if ever, be the case that an act of legal relevance is performed *as* a person is being brain scanned, attorneys increasingly think (or hope) that brain scans preceding or following an act of interest can tell us *something* legally relevant about a person's capacities, predispositions, intentions, or frames of mind.

This article proceeds in three parts. Part I explores a particular context of law and neuroscience: the use of brain scans as evidence of lying or truth-telling. Part II illustrates, discussing the landmark 2010 federal criminal trial *U.S v. Semrau*.[2] That case involved the first federal

(FORTHCOMING), online at www.vanderbilt.edu/lawbrain); Francis X. Shen, *The Law and Neuroscience Bibliography: Navigating The Emerging Field of Neurolaw*, 38 INT'L. J. LEG. INFORM. __ (2011). For additional resources, see the home page of the MacArthur Foundation Law and Neuroscience Project at: www.lawneuro.org.

[2] *Report & Recommendation, U.S. v. Semrau*, U.S. District Court for the Western District of Tennessee (2010) (No. 07-10074). After a 13-day jury trial, on June 17, 2010, the jury found Semrau guilty on three counts of health care fraud in violation of 18 U.S.C. § 1347 and returned a verdict of not guilty on the money laundering counts and the fifty-seven remaining health care fraud counts. *Order Denying Defendant's Motion To Dismiss, Denying Defendant's Motion For Judgment Of Acquittal/To Dismiss And/Or Motion For New Trial, And Denying Defendant's Motion To Strike* at 1 (Nov 23, 2010). As of December 2010, litigation over sentencing continues.

hearing – which one of us (Jones) attended – regarding the admissibility of testimony about brain scans proffered as evidence of whether a person was lying or telling the truth. Part III identifies 5 issues relevant to future encounters between courts and brain scanning evidence. Sufficient scientific progress in addressing issues of experimental design, ecological and external validity, ensuring subject compliance with researcher instructions, false memories, and making individual inferences from group data may one day make brain scan evidence admissible in new legal contexts. But, in the illustrative case of lie detection, not yet.[3]

Still, the *Semrau* case is a poignant reminder that lawyers need not, and indeed often will not, wait for neuroscience research consensus before attempting to introduce brain imaging evidence that may bolster their clients' cases. The stakes are so high, and the emerging neuroscience technologies so novel and alluring, that we are likely to see similar cases more frequently in courtrooms in the years to come. And this means judges must be ready to evaluate, and lawyers to litigate, whether testimony regarding brain scans should be admitted as evidence for new and controversial purposes.

I. BRAIN SCANS, LIES, AND LAW

In this Part we provide context by providing brief overviews of the main brain-based lie detection techniques, and of the scientific and legal contexts for evaluating them.

[3] Judge Pham's report in *Semrau* ultimately resulted in the exclusion of the evidence on the grounds of Federal Rules of Evidence Rule 702 (which governs testimony by experts) and Rule 403 (which states that "although relevant, evidence may be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury …"). After the Report & Recommendation was submitted on May 31, 2010, the defense filed an objection on June 9. On June 10, 2010, the Court adopted the Report & Recommendation, and granted the Government's motion in limine to exclude testimony regarding lie detection tests performed on the defendant. *Order Denying Defendant's Motion To Dismiss*, supra note 2 at 67. Although the evidentiary ruling has no binding precedential value, that did not dampen national attention to the case. National media coverage included: Greg Miller, *fMRI Lie Detection Fails a Legal Test*, 328 SCIENCE 1336 (2010); Alexis Madrigal, *Eyewitness Account of 'Watershed' Brain Scan Legal Hearing*, wired.com (2010); Greg Miller, *Can Brain Scans Detect Lying? Exclusive New Details From Court Hearing*, http://news.sciencemag.org/scienceinsider/2010/05/can-brain-scans-detect-lying-exc.html (2010); Margaret Talbot, *Brain Scans on Trial*, NEW YORKER (May 25, 2010).

A. Brain Based Lie Detection: Techniques

For centuries, humans have tried to improve their ability to detect deception by harnessing the latest technological advances.[4] Brain scanners as lie detectors are thus understandably alluring, and have generated much discussion in scientific and scholarly circles.[5] Although it is beyond the scope of this Article to fully introduce the neuroscience of lie detection, we offer a few basic observations.

There are two prominent techniques for brain based lie detection.[6] The first, *electroencephalography* (or EEG), measures electrical activity in the brain.[7] In EEG studies, researchers place

[4] NATIONAL RESEARCH COUNCIL COMMITTEE TO REVIEW THE SCIENTIFIC EVIDENCE ON THE POLYGRAPH, THE POLYGRAPH AND LIE DETECTION (2003); KEN ALDER, THE HISTORY OF AN AMERICAN OBSESSION: THE LIE DETECTORS (2007).

[5] Neuroscience-based lie detection has received considerable attention in both science and law outlets. See: Giorgio Ganis & Julian Paul Keenan, *The Cognitive Neuroscience Of Deception*, 4 SOCIAL NEUROSCIENCE 465 (2009). This special issue included eight articles, each highlighting a distinct approach to studying the neural correlates of deception. We recommend it for lawyers who want a window into the advancing science in this area. Recommended general reviews of neuroscience-based lie detection evidence include: Anthony Wagner, *Can Neuroscience Identify Lies?, in* A JUDGE'S GUIDE TO NEUROSCIENCE 13 (2010); EMELIO BIZZI, ET. AL., USING IMAGING TO IDENTIFY DECEIT (2009); Kamila E. Sip, Andreas Roepstorff, William McGregor & Chris D. Frith, *Detecting Deception: the Scope and Limits*, 12 TRENDS IN COGNITIVE SCI. 48 (2007); P.R. Wolpe & K. R. Foster, et al., *Emerging Neurotechnologies for Lie-detection: Promises and Perils*, 5 AM. J. BIOETH. 39 (2005); Henry T. Greely & Judy Illes, *Neuroscience Based Lie Detection: The Urgent Need for Regulation*, 33 AM. J. L. & MED. 377 (2007); 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 (2010); Frederick Schauer, *Can Bad Science Be Good Evidence? Lie Detection, Neuroscience and the Mistaken Conflation of Legal and Scientific Norms*, 95 CORNELL L. REV. 1191 (2010); Joseph R. Simpson, *Functional MRI Lie Detection: Too Good to be True?* 36 J. AM. ACAD. PSYCHIATRY LAW 491 (2008); Paul S. Appelbaum, *The New Lie Detectors: Neuroscience, Deception, and the Courts*, 58 PSYCHIATR SERV 460 (2007); Jane Campbell Moriarty, *Visions of Deception: Neuroimages and the Search For Truth*, 42 AKRON LAW REVIEW 739; Archie Alexander, *Functional Magnetic Resonance Imaging Lie Detection: Is a "Brain Storm" Heading Toward the "Gatekeeper"?* 7 HOUSTON J. HEALTH L. & POL'Y 1 (2007).

[6] Ganis & Keenan, supra note 5. Greely & Illes, supra note 5.

[7] It is worth noting that Indian Neuroscientist Champadi Raman Mukundan has developed an EEG procedure known as the Brain Electrical Oscillation Signature (BEOS). BEOS evidence was used in 2008 to convict a woman of murder in a criminal court in India. *Maharastra V. Sharma And Khandelwal*, Sessions Case No. 508/07 (June 12, 2008). In 2010, however, the Supreme Court of India ruled that

electrodes on a subject's skull to detect, localize, and record electrical activity within the brain as a subject performs tasks.[8] The promise, as yet mostly unrealized, is that such technology could be used to determine – on the basis of detectable patterns in the electrical signals in a person's brain – when that person is lying.[9]

The second technique (and the one at issue in *Semrau*, discussed in the next Part) is *functional magnetic resonance imaging* (or fMRI).[10] fMRI detects changes in hemodynamic (literally "blood movement") properties of the brain as a subject engages in specific mental tasks.[11] fMRI allows researchers, and thus potentially courts, to know "which regions of the brain are working, how much, and for how long, during particular tasks."[12]

It is important to recognize that what one might learn from an fMRI study about the truthfulness of a subject depends, critically, on a variety of factors. These include: 1) the experimental design (i.e., the paradigm used, and the specific set of tasks); 2) proper execution of the design; and 3) proper interpretation of the results.

A number of paradigms, across many different labs, have been employed to date. These include: 1) "forced-choice lies" (i.e., responding yes when the truth is no and vice versa); 2) spontaneous lies (i.e., saying Chicago when the true answer is Seattle); 3) rehearsed and

---

compulsory administration of such evidence – narco analysis, brain mapping and polygraph tests – violated Article 20(3) of the Constitution of India, violated the right to privacy guaranteed by Article 21, and was a violation of substantive due process. *Selvi V. Karnataka,* Supreme Court of India, Criminal Appeal No. 1267 of 2004 (2010).

[8] At least one U.S. court has encountered this type of lie detection evidence before. Neuroscientist Lawrence Farwell's "brain fingerprinting" technology, which measures an electrical signal called the P300 wave (because it occurs about 300 to 600 milliseconds after a stimuli), was admitted by the trial judge in an Iowa case. The neuroscientific testimony was not considered directly on appeal, but the case nonetheless drew national attention for the very fact that such evidence had been admitted. *Harrington v. State*, 659 N.W.2d 509 (Iowa 2003). See Greely & Illes, supra note 5 at 387-8.

[9] On developments in this technique, see, e.g., J. Peter Rosenfeld, *'Brain Fingerprinting': A Critical Analysis*, 4 SCI. REV. OF MENTAL HEALTH PRACTICE 20 (2005); J.P. Rosenfeld, M. Soskins, G. Bosh & A. Ryan, *Simple, Effective Countermeasures To P300 Based Tests Of Detection Of Concealed Information*, 41 PSYCHOPHYSIOLOGY 205 (2004).

[10] For an introduction to fMRI for a legal audience, see: Jones, et. al, supra note 1. For discussion of fMRI in the context of lie detection, see Marcus E. Raichle. *An Introduction to Functional Brain Imaging in the Context of Lie Detection, in* USING IMAGING TO IDENTIFY DECEIT 3 (2009).

[11] For a brief overview, see Jones, et. al., supra note 1 at 5.

[12] *Id*.

memorized lies (feigning memory impairment); and 4) several variations of the so-called "Guilty Knowledge Test" (in which subjects who have knowledge of the relevant facts will theoretically exhibit different neural responses to relevant questions, as compared to neutral control questions[13]).

B. Brain Based Lie Detection: Scientific and Legal Views

Scientists and lawyers are engaged in fundamentally different enterprises, which reflect different goals and guiding principles.

In the domain of science, the question is whether researchers have convincingly demonstrated that brain based lie detection techniques yield valid and reliable results. But this question immediately subdivides, according to context.

On one hand, a recent study published in the *Proceedings of the National Academy of Sciences* (PNAS) demonstrates quite forcefully that people who frequently lied about whether they had correctly predicted the result of a coin toss (reporting accurate predictions at far more frequently than chance) can be distinguished, by their brain activity alone, from those who successfully predicted coin flips only at chance (i.e. roughly 50% of the time).[14] On the other hand, these results distinguish a *group* that often lied from a *group* that rarely (if ever) lied. The brain measures did not enable the researchers to identify when a *single* person was lying on a *single* question.

The scientific literature reflects a fairly broad scientific consensus that no brain-based technique is particularly effective for determining whether an individual is lying in response to a particular question (which, of course, will generally be the important issue in legal contexts). For example, neuroscientist Anthony Wagner concluded, in a comprehensive 2010 review of the literature, that "there are no relevant published data that unambiguously answer whether fMRI-based neuroscience methods can detect lies at the individual-subject level."[15]

---

[13] For a more detailed description of the experimental paradigms used see Simpson, supra note 5 at 492; Sip, et. al. supra note 5.

[14] Joshua D. Greene & Joseph M. Paxton, *Patterns Of Neural Activity Associated With Honest And Dishonest Moral Decisions*, 106 PROC. NAT'L ACAD. SCI. 12506 (2009).

[15] Wagner, supra note 5 at 14. Wagner identified and reviewed 28 relevant peer reviewed publications "reporting unique fMRI or PET data sets that examine brain responses during putative 'deception versus truth telling.'" Relatedly, in a 2009 American Academy of Arts and Sciences volume on neuroimaging and lie detection, experts from both science and law held "a dim view of lie detection with fMRI," finding it "unreliable" and giving some reason to think that in the case of "lie detection

However, it is essential to recognize that law's concern is not solely whether the techniques are up to the justifiably robust standards of science. Law's concern is whether the techniques are meaningfully better *than the next best alternative technique currently deployed in the legal process*[16] – which is often having a group of untrained jurors sit passively as they watch and listen to witnesses.

Moreover, brain based lie detection could potentially be relevant with respect to a very wide variety of issues, such as:[17]

- A past act or experience (e.g., I was not at the scene of the crime)
- A current physical state (e.g., I am in pain and am not faking it)
- Eye-witness testimony(e.g., I saw him at the scene of the crime)
- Prediction of future behavior (e.g., at a parole hearing: I do not intend to do the bad act again)
- Current mental state (e.g., at sentencing: I am remorseful for the crime I did)
- Past mental state (e.g., I did not *knowingly* do the bad act)

And each of these permutes with a particular legal setting (e.g. sentencing vs. parole hearing vs. criminal trial), raising distinct questions about evidentiary standards, which can (and often do) logically vary with legal contexts, stakes, and issues.

As a consequence, we believe that when a diversity of scientific techniques meets a diversity of legal issues and contexts, the legal system ought to conduct its legal analyses on a case-by-case basis – that is, with regard to a particular technology, employing a particular

---

through fMRI … problems seem insurmountable." Bizzi, et. al., supra note 5 at 2. This is not to say we have not learned much about the cognitive neuroscience of deception. For instance, these studies consistently find greater activation in the prefrontal and anterior cingulate regions of the brain. Wagner, supra note 5 at 15. See also Sip, supra note 5 at 50 and Simpson, supra note 5 at 492. Nor is it to say that legal and scientific evidentiary standards should be identical. See: Owen D. Jones, *Law, Evolution, and the Brain: Applications and Open Questions*, 359 Phil. Trans. R. Soc. Lond. B 1697 (2004).

[16] See Schauer, supra note 5. Jones, supra note 16.

[17] Note too that brain based lie detection evidence might be offered by either prosecution or defense, or by either party in a civil suit. Indeed, in a 2008 review, psychiatrist Joseph Simpson observed that "Given the current state of the field and the unresolved practical matters mentioned herein, the forensic role of the technique is likely to be limited to the civil arena, with both sides agreeing to have one or more parties consent to undergo the test." Simpson, supra note 5 at 497. In addition to this list of courtroom possibilities, it is not hard to imagine an even longer list of theoretically important uses in related areas, e.g. interrogation, police investigations, settlement negotiations, and so on.

experimental paradigm, applied to a particular question of legal relevance. We illustrate in the next Part.

II. *U.S. v. SEMRAU*

A. Background

In *U.S. v. Semrau* the government charged psychologist Dr. Lorne Semrau with Medicare/Medicaid fraud. Proving fraud requires proving that Semrau knowingly violated the law. And Semrau's defense was built, in part, around brain scan results that allegedly demonstrated he was telling the truth when he claimed (some years after the fact) that even though he had mis-billed for services, he did not do so intending to defraud the government.

By way of background, Semrau owned two businesses, each of which contracted with nursing homes in Tennessee and Mississippi to provide the psychologists and psychiatrists necessary to dispense prescriptions and provide mental health care. After an investigation by the United States Attorney's Health Care Fraud Task Force in the Western District of Tennessee, the government alleged that between 1999 and 2005 Semrau had manipulated Medicare and Medicaid billing codes to inflate payments, resulting in $3 million worth of fraud.[18] Semrau entered a plea of not guilty.

The central legal question in the case concerned Semrau's mental state at the time of his acts: between 1999 and 2005, did Semrau "*knowingly* devise a scheme or artifice to defraud a health care benefit program in connection with the delivery of or payment for health care benefits, items, or services?"[19]

---

[18] See *Report & Recommendation*, supra note 2 . See also: United States Attorney's Office, Western District of Tennessee, *Federal Jury Convicts Psychologist for False Billings to Medicare/Medicaid*, Press Release (June 28, 2010). http://memphis.fbi.gov/dojpressrel/pressrel10/me062810.htm . The Government alleged that "to carry out this scheme, Dr. Semrau directed his billing personnel to bill CPT codes that were different from the codes marked by the treating psychiatrists, and instructed the psychiatrists to claim a separate CPT code for AIMS tests." *Report & Recommendation*, supra note 2 at 4.

[19] The intent question is most relevant to the fMRI lie detection analysis, so we speak only to that aspect of the defense in this Article. In addition, however, Semrau's Defense argued that "his actions were reasonable under the circumstances because the CPT codes were confusing and unclear, and claims he followed instructions and guidance provided by CIGNA and CAHABA representatives." *Report & Recommendation*, supra note 2 at 5. Dr. Semrau's lawyer was straightforward with the Court that this was a case that would "boil down almost totally to whether or not when

To bolster Semrau's credibility – in his assertion that he had not knowingly engaged in prohibited billing practices – defense attorney Houston Gordon contacted Dr. Stephen Laken, Founder and CEO of Cephos Corporation.[20] Since 2004, Dr. Laken had been developing fMRI lie detection technology, and beginning in 2008 Cephos marketed the product commercially. During December 2009 Laken worked with attorney Gordon to develop a set of Specific Incident Questions (SIQ) that Dr. Semrau would answer in the scanner.[21] Examples of the questions include:[22]

- Did you bill CPT Code 99312 to cheat or defraud Medicare?
- Did you enter into a scheme to defraud the government by billing for AIMS tests conducted by psychiatrists under CPT Code 99301?

Neutral questions – against which the answers to SIQs would be compared – were also used.[23] Examples of neutral questions include: Do you like to swim? Are you over age 18?[24] The Defense and Laken co-designed the tasks and the Specific Incident Questions without the knowledge of the prosecution (a fact that would later factor into the Court's analysis).

On December 30, 2009, Semrau traveled to the Cephos office in Framingham, Massachusetts, for his initial brain scanning session. Following data analysis, Laken made two conclusions. First, as to whether Semrau was being honest when he claimed that he had not

---

Dr. Semrau takes the stand and testifies as to what he did and why he did it and when he did it and what he was thinking at the time, whether or not what he's saying is true." *Transcript of Proceedings Vol. IV* at 63, *U.S. v. Semrau*, U.S. District Court for the Western District of Tennessee (May 13, 2010) (No. 07-10074).

[20] http://www.cephoscorp.com/.

[21] Question development involved rehearsal with Semrau himself. See *Transcript of Proceedings Vol. I* at 68, *U.S. v. Semrau*, U.S. District Court for the Western District of Tennessee (May 13, 2010) (No. 07-10074).

[22] In this case, they developed two sets of SIQs, one for each of two specific incidents: "The first one was does he believe that he was trying to fraud or was he trying to commit fraud against the government. And the second one was whether or not he inappropriately used AIMS [Abnormal Involuntary Movement Scale] testing and whether he was using that in a way that he knew he shouldn't be using that." *Transcript of Proceedings Vol. I*, supra note 22 at 94. Dr. Laken readily admitted on the stand that this overall statement did not allow him to assess truthfulness on any one of the questions individually. *Transcript of Proceedings Vol. I*, supra note 22 at 138-140.

[23] *Transcript of Proceedings Vol. I*, supra note 22 at 72. "Control" questions were also employed, but Dr. Laken testified that they were only used as space fillers and answers to the control questions did not factor into the analysis.

[24] Steven J. Laken, *U.S. v. Semrau fMRI Testing Report*, 8 (2010).

knowingly defrauded the government, Laken concluded that "it appeared his brain showed that he was telling the truth."[25] Second, as to whether or not Semrau knew he was incorrectly billing for services that should not have been separately billed, Laken found that "it appeared that he was lying when he said he was telling the truth."[26] This second conclusion was obviously not the result for which Semrau's defense team had hoped.

After analyzing the data further, Laken contacted Attorney Gordon's office and offered to do a third scan, specifically on the second issue, of whether Semrau had knowingly incorrectly billed for certain psychiatric tests administered. Laken justified the additional scan on the grounds that Semrau was fatigued for the second scan, and this may have invalidated the results.[27] Laken shortened the questions for the third scan, conducted on January 12, 2010. After the third scan, Laken newly concluded that "we believe that Dr. Semrau's brain indicates that he was telling the truth when he said that he is telling the truth about not inappropriately performing AIMS testing."[28]

In light of these brain scan results, the defense team decided to have Laken testify. To clarify, Laken was not offered as a witness who could testify *directly* about Semrau's past mental state. Instead, he was to testify about the truthfulness of Semrau's claim, in *December 2009 and January 2010,* about his state of mind across 1999 through 2005.

In Laken's own words: "What we can say is … that we believe his brain – he believes that he is telling the truth at least."[29] Verifying the truthfulness of a belief, of course, doesn't provide the court with information on so-called "ground" truth, i.e. whether the belief is true to begin with. Rather, as Laken explained, "If [experimental subjects] say that this is the truth, then I believe them that this is the truth. At least that's what they are telling me is the truth. These are the *truths of the statements.*" (emphasis added).[30] The truth of Semrau's *statements* about mental states is, of course, distinct from the fact relevant to the case: Semrau's actual mental states at the time of the billing.[31]

---

[25] *Transcript of Proceedings Vol. I*, supra note 22 at 95.
[26] *Id.*
[27] Laken admitted that fatigue could have made the first scan inaccurate too. *Transcript of Proceedings Vol. I*, supra note 22 at 152.
[28] *Transcript of Proceedings Vol. I*, supra note 22 at 97.
[29] *Transcript of Proceedings Vol. I*, supra note 22 at 99.
[30] *Transcript of Proceedings Vol. I*, supra note 22 at 70.
[31] Laken made clear on the stand that his data were not meant to supplant other forensic evidence, but simply to improve, even if slightly, one's assessment of Semrau's

B. The Admissibility Of The Evidence

On May 13 and 14, 2010, Federal Magistrate Judge Tu Pham , conducted the hearing on whether the brain based lie detection evidence should, at a later date, be heard by the empanelled jury.[32] Laken testified for the defense. Dr. Marc Raichle (a neuroscientist at Washington University in St. Louis) and Dr. Peter Imrey (a biostatistician of the Cleveland Clinic) were rebuttal witnesses for the government.[33]

Judge Pham considered both the relevance of Laken's proferred testimony, under Federal Rules of Evidence Rule 702, and its probative value, under Rule 403. In applying Rule 702, federal courts perform a two-prong gatekeeping role for expert scientific evidence, first evaluating the *reliability* and then the *relevance* of the testimony.[34] Because the Court did not find the proffered testimony in *Semrau* to be reliable, it did not reach the relevance prong, and thus we exclude the latter from our discussion.

In assessing reliability, the Court's analysis applied the *Daubert* test and considered four, non-exclusive factors:[35]

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

---

truthfulness. *Transcript of Proceedings Vol. II* 237, *U.S. v. Semrau*, U.S. District Court for the Western District of Tennessee (May 13, 2010) (No. 07-10074).

[32] In federal courts such hearings are known as "Daubert" hearings because federal court judges evaluate scientific evidence according to the principles laid out by the Supreme Court in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993). For more on *Daubert* in the context of brain science, see Edward J. Imwinkelried, *Serendipitous Timing: the Coincidental Emergence of the New Brain Science and the Advent of an Epistemological Approach to Determining the Admissibility of Expert Testimony*, <this volume>. More generally see FAIGMAN ET AL., MODERN SCIENTIFIC EVIDENCE: THE LAW AND SCIENCE OF EXPERT TESTIMONY (2010-2011 Ed.).

[33] Disclosure: both of these witnesses are known to the authors, as colleagues within the MacArthur Foundation Law and Neuroscience Project.

[34] Fed.R.Evid. 702. *Daubert*, supra note 33.

[35] *Report & Recommendation*, supra note 2 at 19 (citing Daubert, supra note 33 at 593-94; First Tenn. Bank Nat'l Ass'n v. Barreto, 268 F.3d 319, 334 (6th Cir. 2001).).

Judge Pham found that factors 1 and 2 were satisfied, while factors 3 and 4 were not.[36] He therefore concluded that "at least at this early stage in its development, fMRI-based lie detection does not satisfy the requirements of Rule 702."[37]

Judge Pham's report was, in our view, thorough, well reasoned, and right in its conclusions on each of these four factors.[38] There was relatively little dispute that the theory and technique presented by Laken had indeed been tested, and the issue of peer review was also won by the defense.[39]

As to whether the error rates are known, however, the defense arguments were not as strong. Analogizing to a 9th circuit polygraph case, *U.S. v. Cordoba*, Judge Pham ruled that "here, like in *Cordoba*, the error rate of real-life fMRI-based lie detection is unknown."[40] Moreover, the Court was troubled by Laken's choice to do a third test (following an uncomfortable finding), when the protocol had only called for two brain scanning tests. The Court observed that Laken's "decision to conduct a third test begs the question whether a fourth scan would have revealed Semrau to be deceptive again."[41] Judge Pham found that "lack of controlling standards in the industry for real-life exams, and Laken's apparent deviation from his own protocols are negative factors in the analysis of whether fMRI-based lie detection is scientifically valid."[42]

---

[36] It might also be the case that even if fMRI lie detection evidence passes the Daubert hurdle, it may still face a hearsay objection. For a discussion of this possibility, see: Jeffrey Bellin, *The Significance (If Any) for the Federal Criminal Justice System of Advances in Lie Detector Technology*, 80 TEMP. L. REV. 711 (2007).

[37] *Report & Recommendation*, supra note 2 at 21-22.

[38] Judge John McCalla held the same view when evaluating the defense's Motion for a New Trial. One of the arguments for a new trial was the exclusion of the lie detection evidence, but Judge McCall found that the testimony was properly excluded on both Rule 702 and Rule 403 grounds. *Order Denying Defendant's Motion To Dismiss, Denying Defendant's Motion For Judgment Of Acquittal/To Dismiss And/Or Motion For New Trial, And Denying Defendant's Motion To Strike* at 1 (Nov 23, 2010). *Report & Recommendation*, supra note 2 at 22.

[39] In a single paragraph in the Report, Judge Pham found that "the underlying theories behind fMRI-based lie detection are capable of being tested, and at least in the laboratory setting, have been subjected to some level of testing. It also appears that the theories have been subjected to some peer review and publication, particularly within the last five years, as evidenced by the articles coauthored by Dr. Laken." *Report & Recommendation*, supra note 2 at 22.

[40] *United States v. Cordoba*, 194 F.3d 1053, 1059-60 (9th Cir. 1999)

[41] *Report & Recommendation*, supra note 2 at 27.

[42] *Report & Recommendation*, supra note 2 at 27.

On the issue of general acceptance, the defense argued that in the Sixth Circuit, "general acceptance within a particular scientific community does not mean unanimity or consensus."[43] The government countered, both through its two expert witnesses and through a number of scholarly articles submitted to the court, that scholars viewed neuroscience lie detection generally, and Cephos's technology in particular, as not ready for coutroom use.[44] Judge Pham was persuaded, and in his Report quoted several of these articles to support his conclusion that "no doubt in part because of its recent development, fMRI-based lie detection has not yet been accepted by the scientific community."[45]

Finally, and independently under Rule 403, the court agreed "that the probative value of Dr. Laken's testimony is substantially outweighed by the danger of unfair prejudice to the government."[46] This was due, in part, to the fact that the fMRI test was obtained unilaterally.[47] The court also took notice of the inability of the Cephos approach to provide the court with information on Semrau's truthfulness on particular questions (and not just overall).[48] In addition, the government, citing *Scheffer*, argued that it "is simply infringing on the province of the jury to make the ultimate credibility determination of testimony."[49]

---

[43] *Transcript of Proceedings Vol. I*, supra note 22 at 9.

[44] *Addendum To United States' Motion In Limine And Memorandum In Support To Exclude Defendant's Expert Witness Testimony Of Dr. Steven Laken And Request By The United States For A Daubert Hearing* at 1, *U.S. v. Semrau*, U.S. District Court for the Western District of Tennessee (2010) (No. 07-10074).

[45] *Report & Recommendation*, supra note 2 at 28.

[46] *Report & Recommendation*, supra note 2 at 29. In making its 403 ruling, the court relied on United States v. Sherlin, 67 F.3d 1208, 1217 (6th Cir. 1995) and United States v. Thomas, 167 F.3d 299, 308-09 (6th Cir. 1999).

[47] Judge Pham observed that "While the Sixth Circuit Court of Appeals has not addressed fMRI-based lie detection specifically, courts in this circuit have consistently found that the high risk of unfair prejudice associated with the admission of testimony regarding unilaterally obtained polygraph results will preclude such testimony from being admissible." *Report & Recommendation*, supra note 2 at 29.

[48] The court reasoned that "based on his inability to identify which SIQs Dr. Semrau answered truthfully or deceptively, the court fails to see how his testimony can assist the jury in deciding whether Dr. Semrau's testimony is credible." *Report & Recommendation*, supra note 2 at 33.

[49] *Transcript of Proceedings Vol. I*, supra note 22 at 12. As Justice Thomas wrote in *United States v. Scheffer*, a case upholding a military evidentiary rule excluding polygraph evidence in court-martial proceedings, "A fundamental premise of our criminal trial system is that "the *jury* is the lie detector." United States v. Barnard, 490 F.2d 907, 912 (C.A.9 1973) (emphasis added), cert. denied, 416 U.S. 959, 94 S.Ct. 1976, 40 L.Ed.2d 310 (1974). Determining the weight and credibility of witness

Despite their many disagreements, both sides in *Semrau*, and indeed Judge Pham as well, agreed that the neuroscience in this area is fluid and that someday the science might well advance sufficiently enough to pass the *Daubert* test. Judge Pham wrote in a footnote that "in the future, should fMRI-based lie detection undergo further testing, development, and peer review, improve upon standards controlling the technique's operation, and gain acceptance by the scientific community for use in the real world, this methodology may be found to be admissible even if the error rate is not able to be quantified in a real world setting."[50]

Such evidence may also arise in legal contexts quite different from *Semrau*, where evidentiary rules and substantive issues will require distinct analyses.[51] We should also remember that legal change might well come from legislative action rather than a judge's chambers. Already at least one state (New York) has a state legislator who has proposed a modification to state law that would exclude certain types of brain based lie detection evidence from being admissible in certain situations.[52]

III. FIVE ISSUES AFFECTING ADMISSIBILITY

The analysis of admissibility of brain scanning evidence in *Semrau* was relatively straightforward, in the end. However, close study of the case and transcript, in light of the brain based lie detection literature to date, suggests that there are a number of broader issues that will – or at least should – emerge when courts consider the admissibility

testimony, therefore, has long been held to be the "part of every case [that] belongs to the jury, who are presumed to be fitted for it by their natural intelligence and their practical knowledge of men and the ways of men." 1267 Aetna Life Ins. Co. v. Ward, 140 U.S. 76, 88, 11 S.Ct. 720, 724-725, 35 L.Ed. 371 (1891). United States v. Scheffer, 523 U.S. 303 (1998).

[50] *Report & Recommendation*, supra note 2 at 31.

[51] Indeed, the summer of 2010 also saw an attempt in New York to introduce similar evidence. *Wilson v. Corestaff* (2010, Kings County, Supreme Court of the State of New York, Index No. 32996/07). During his testimony, Dr. Laken also referenced testifying in a South Carolina post-conviction relief case. *Transcript of Proceedings Vol. I*, supra note 22 at 119-120.

[52] In 2009 New York Assemblyman Michael Benjamin proposed bill A09154: "An act to amend the criminal procedure law, in relation to admissibility of magnetic resonance imaging (MRI) brain scans in criminal proceedings." The stated purpose of the bill was to "ban the use of magnetic resonance imaging (MRI) brain scans in a criminal proceeding where a defendant's or witness's truthfulness or knowledge of a specific event is at issue." http://assembly.state.ny.us/leg/?bn=A09154

of testimony regarding brain scans. Here, we identify, and then briefly explain, five of these issues:

1. What did the experimental task actually measure?
2. How "ecologically valid" and "externally valid" were the experimental conditions?
3. To what extent did the subject or subjects of interest complete the tasks in the scanner as instructed by the researchers?
4. What statistical procedures were used, and how well do these procedures support the claims being made?
5. If group-averaged data were proffered, can one draw from them legitimate inferences about this one individual?

1. What did the experimental task actually measure?

Some brain scans are purely anatomical. (Examples include x-rays and CT-scans.) They are intended to show the physical condition of the brain in ways that, at times (such as when there is massive tissue damage) can lead to inferences about function.

Other brain scanning techniques, of the sort described earlier in this Article, are both anatomical and – in particular – *functional*. That is, they provide data about what the brain is actually doing, moment by moment, as it performs specific tasks under precise experimental conditions.

In the latter case, the courtroom usefulness of an assessment of brain function depends not just intimately – but virtually entirely – on a logical and demonstrable connection between the tasks as performed in the scanner and the legal issue at hand. Put another way, statistically significant findings may advance a scientific field, but can only be as legally meaningful as the legal appropriateness of the experimental protocols. Specifically, it's a question of: was the brain actually doing what the expert testifying in court *claims* it was doing during the experiment?

For instance, to illustrate with lie detection, can one be reasonably sure that the brain activation pattern being reported is being caused by "lying" (or the absence of lying) as opposed to being caused by some other mental process? In the case of lie detection, one fundamental challenge to courtroom applicability is that the majority of neuroscience lie detection research to date has relied on an "instructed lie" experimental paradigm in which researchers tell subjects when to be

dishonest in the scanner.[53] It is not clear whether, when using an instructed lie paradigm, courts can draw credible inferences about real world "lying".

Neuroscientist Nancy Kanwisher, for instance, argues that "making a false response when you are instructed to do so isn't a lie, and it's not deception. It's simply doing what you are told. We could call it an 'instructed falsehood.'"[54] And neuroscientist Kamila E. Sip and colleagues similarly argue that the "absence of this intentional aspect of deception in the experiments is … more than a mere experimental confound."[55] It fundamentally changes what the brain is being asked to do. Researchers, in this view, are indeed measuring *something* – but they are not necessarily measuring "lying".[56]

Second, courts should pay great attention to the interaction of deception detection and memory. It is not hard for any of us to imagine a time when we may have "lied" without knowing it. Thus, courts must be assured that the proffered evidence can distinguish between the mental processes of (1) mis-remembering but not deliberately lying vs. (2) remembering correctly, but deliberately lying. Moreover, we don't yet know how rehearsal of a lie over time, involving activation of memory systems, affects brain chemistry.[57] Until we better understand the

---

[53] Sip, et. al, supra note 5.

[54] Nancy Kanwisher, *The Use of fMRI in Lie Detection: What Has Been Shown and What Has Not, in* USING IMAGING TO IDENTIFY DECEIT 12 (2009).

[55] Sip, et. al., supra note 5 at 48.

[56] Laken's position in *Semrau* was that "A lie is the intentional act of deceit," and that even when instructed to do so, subjects are still intentionally deceiving. Instructed lies, in Laken's view, are real lies. *Transcript of Proceedings Vol. I*, supra note __ at 159. But because this view is contested courts must be attuned to what researchers are telling subjects to do in the fMRI scanner. When this question comes up in future litigation, it may well be the case that new research has begun to address these issues. As Sip, et. al. note, this is a problem that can be corrected through improved experimental paradigms. Sip, et. al., supra note 5 at 52 (noting that "the field will benefit from the study of this aspect of deception in isolation."). Indeed, at least one fMRI study that we are aware of has developed a novel method to address this issue and uncover real, non-instructed lies. See Greene & Paxton, supra note 15.

[57] It is possible that "memory processes, rather than deception, may account for group-level effects in some studies of deception." Wagner, supra note 5 at 30. For general discussion of memory as a complicated, and often mistaken, process of re-remembering and re-storing, see DANIEL L. SCHACTER, THE SEVEN SINS OF MEMORY: HOW THE MIND FORGETS AND REMEMBERS (2001); Elizabeth F. Loftus, *Planting Misinformation In The Human Mind: A 30-Year Investigation Of The Malleability Of Memory,* 12 LEARN. MEM. 361 (2005); N. Abe, J. Okuda, M. Suzuki, H. Sasaki, T. Matsuda, E. Mori, M. Tsukada, & T. Fujii, *Neural Correlates Of True Memory, False Memory, And Deception*, 18 CEREBRAL CORTEX 2811 (2008).

relationship between deception and memory retrieval, courts should be very wary of accepting evidence about truthfulness related to long-past events.

Finally, the areas of brain activation associated with a particular experimental task may be part of a *general* neural system. Researchers may not have isolated the particular system they claim to.[58] If an area, or areas of activation, are not specific to the legally relevant mental process, then we are left unable to disambiguate it from other mental processes that might be causing the observed brain activation pattern.

As this discussion illustrates, courts will have multiple reasons to closely consider whether the proffered brain scanning evidence – however accepted the technique is generally – resulted from experimental procedures that were designed to effectively isolate the brain activity associated with the specific issue of legal relevance.

2. How "ecologically valid" and "externally valid" were the experimental conditions?

Court's want to know how useful proferred evidence may be to resolving a contested legal issue. Consequently, they will – when encountering brain scan evidence – want to approach the admissibility questions with a skeptic's eye for assessing ecological and external validity.

A study's "ecological validity" is a measure of how well the laboratory conditions mimic real world situations. A study's "external validity" is a measure of the ability to generalize about lab findings to the population (or individual) of interest. Although high ecological validity may often correlate positively with high external validity, this is not always the case and thus the two issues should both be considered.[59]

[58] In the context of lie detection, these general systems, as Dr. Raichle described them in his testimony, may be "systems concerned with attention switching and salience and working memory. … So in and of itself, these are not unique to lie detection itself." *Transcript of Proceedings Vol. II*, supra note 32 at 265. Dr. Raichle later made a similar point: "this paradigm doesn't stand in isolation from neuroscience or cognitive neuroscience. It stands in juxtaposition or as part of an overall scientific investigation that has dealt with these systems and paradigms that are remarkably close to the ones he's talking about that have nothing to do with lie detection." *Transcript of Proceedings Vol. II*, supra note 32 at 312.

[59] For instance, a mock jury study may have great ecological validity if its experimental conditions mimicked real world conditions, but still have poor external validity for a general population if it used only college students.

Using brain-based lie detection as an example, it has been noted that no laboratory study has been able to replicate the real-world, ecologically valid stakes (such as avoiding imprisonment) that often accompany lying.[60] In *Semrau*, when Dr. Laken was asked on cross examination about ecological validity, he replied that "whether they're lying about biographical things, whether they're lying because they've been told a lie or not told a lie, whether they're lying about playing cards -- all of these things seem to be activating the same region. So it appears that irregardless of what type of lie, the same brain regions are out there."[61] This statement reflects an assumption that a lie – whether told in a scanner without consequence, or in the real world with great consequence – should be expected to activate the same brain regions. While theoretically plausible, there is no general acceptance of such an assumption.

As to external validity in *Semrau*, the government pointed out that the algorithm developed by Laken was created from laboratory studies of subjects between the ages of 18 and 50, while Semrau was 63. This raised the question whether brain-based results from younger cohorts could validly serve as reference points for someone considerably older. During cross examination, U.S. Atty. Canale hit upon this age effect, asking Dr. Laken, "So the application of your technology to somebody who is 63 years old is unknown?" to which Laken replied: "Is unknown. That's correct."[62] Judge Pham cited this exchange in a footnote in his Report, and we expect that concerns about external validity will be a part of every attempt to introduce neuroscience based lie detection evidence.

Returning to the general point, in every legal context in which functional brain scan evidence is offered, courts must inquire about ecological and external validity. To be legally relevant, the experimental design must be close enough to real world conditions to be applicable to the case, *and* the researcher must be able to credibly generalize from the

---

[60] See Wagner, supra note 5 at 22. Neuroscientist Elizabeth Phelps argues that "This problem of applying laboratory findings to other, more everyday and/or personally relevant and important circumstances is a challenge for all studies of human behavior. However, addressing this challenge becomes especially critical when we attempt to use our laboratory findings to generate techniques that can potentially impact individuals' legal rights. Until this challenge can be addressed, the use of fMRI for lie detection should remain a research topic, instead of a legal tool." Elizabeth Phelps, *Lying Outside the Laboratory: The Impact of Imagery and Emotion on the Neural Circuitry of Lie Detection, in* USING IMAGING TO IDENTIFY DECEIT 20, Bizzi, et. al., eds. (2009).

[61] *Transcript of Proceedings Vol. IV*, supra note 20 at 40.

[62] *Transcript of Proceedings Vol. II*, supra note 32 at 190.

subjects on which the experiments were conducted to the subject or subjects of interest in the courtroom.

3. To what extent did the subject or subjects of interest complete the tasks in the scanner as instructed by the researchers?

In any functional brain imaging experiment, researchers must ensure, sometimes going to great lengths, that their research subjects in the scanner complete the tasks as instructed. For example, subjects are always instructed to remain still in the scanner because movement during scan acquisition may make the data unusable.[63] Data from subjects who are unable to remain sufficiently motionless cannot be readily interpreted.

While moving in the scanner is typically not done intentionally, subjects may also choose, for a variety of reasons, not to follow the researcher's instructions. Some of this may be due to relatively innocent motives such as wanting to get through the experiment as quickly as possible by clicking a response button and not carefully listening to directions. But it may also be that a subject intentionally engages in "countermeasures", behaving in the scanner in a way that is antithetical to the given instructions. Thus, when encountering brain based evidence, courts must consider how readily the researchers could have detected non-compliance with instructions.

Lie detection provides a clear illustration of this general point. In their review of the polygraph, a National Academies expert panel found that "countermeasures pose a potentially serious threat to the performance of polygraph testing because all the physiological indicators measured by the polygraph can be altered by conscious efforts through cognitive or physical means."[64] The same concerns should be raised about brain based lie detection because at this point we simply don't know enough about the potential effectiveness of fMRI countermeasures.[65]

Courts will be confronted with the question: is fMRI lie detection analogous to, or distinguishable from, its polygraph precursor. In the words of attorney Gordon, the defense claimed that, unlike an

[63] Cameron S. Carter, Stephan Heckers, Thomas Nichols, Daniel S. Pine, and Stephen Strother, *Optimizing the Design and Analysis of Clinical Functional Magnetic Resonance Imaging Research Studies*, 64 BIOL PSYCHIATRY 842 (2008) (noting that although data analysis programs can correct for between-scan subject movement, movement during scanning can still pose a significant problem for the signal to noise ratio).

[64] National Research Council, supra note 4, Executive Summary at 4.

[65] Greely & Illes, supra note 5 at 404-5.

individual who can alter his polygraph test, in the scanner a subject "can't manipulate his brain."[66] The government, of course, disagreed and the court rightly analogized in this case to the polygraph. But as the science of brain-based lie detection techniques advances, courts must revisit the polygraph analogy question.

Courts, beyond the lie detection context, must be aware not only of possible countermeasures to a given experimental paradigm, but to all other subject-specific behavior in the scanner (e.g. movement, failure to comprehend instructions, and so on) that may invalidate the results and thus the proffered interpretation of the brain scan evidence. The experimental design must be executed properly.

4. What statistical procedures were used, and how well do these procedures support the claims being made?

A large number of complex statistical analyses are used to translate data obtained from the brain scanning device into the graphical image displayed in court.[67] Thus, there are a correspondingly large number of questions that can be asked about the validity of these statistical procedures. In general, as in any problem of statistical inference, a court should be made aware of the assumptions and conventions being employed in the analysis, as well as the statistical uncertainty of the researcher's conclusions.[68] In short, courts need to

[66] *Transcript of Proceedings Vol. IV*, supra note 20 at 64. Laken addressed countermeasures at length during cross-examination, stating that: "… we make countermeasures into two different types of countermeasures, physical countermeasures and mental countermeasures. So physical countermeasures are things like moving your fingers or your toes, and mental countermeasures are pretending like you're in a church or you didn't do what it is that you say that you did do. And in the studies that we have done, we encourage people to commit countermeasures. We say, by the way, if you beat us, you get extra money. So do whatever it takes. Now, we don't know what countermeasures are because I certainly don't. I have no idea how to activate my anterior cingulate." *Transcript of Proceedings Vol. II*, supra note 32 at 240. In his closing argument, defense attorney Gordon argued that the fMRI lie detection evidence was "hard scientific evidence as opposed to somebody's subjective supposition of what took place. … There's nothing that Dr. Laken does to manipulate it, and there's nothing that Dr. Semrau can do to manipulate it. So it's not the same thing as the polygraph, even though the Government wants to make it that way." *Transcript of Proceedings Vol. IV*, supra note 20 at 64-65.

[67] For an introduction to the types of statistical procedures used, see Jones, et. al., supra note 1.

[68] For a general introduction to statistical inference in the context of law, see David H. Kaye & David A. Freedman, *Reference Guide on Statistics, in* FEDERAL JUDICIAL COLLEGE REFERENCE MANUAL ON SCIENTIFIC EVIDENCE (2nd Ed. 2000).

understand the validity of the statistical analyses producing the brain images and their interpretation.

To illustrate using *Semrau*, bio-statistician Dr. Peter Imrey usefully defined validity as "the extent to which one can exclude: reverse causation, chance, selection, measurement bias, confounding bias from study conclusions, and theoretically justify generalization to contexts outside the specific."[69] We have touched on many of these validity issues, all of which should be addressed by courts in future litigation on neuroscience evidence.

In addition, courts may find it useful to consider this series of questions, adapted from concerns raised by Imrey in *Semrau*, about the procedures used to produce and analyze the brain data: [70]

- *Theoretical Rational:* Does the proffered brain scan study have a plausible theoretical rationale, that is, a proposed brain mechanism consistent with current physiological, neurobiological, and psychological knowledge? Are there plausible alternative theoretical rationales regarding the underlying mechanisms that make competing empirical predictions about how the technique performs? What is the weight of evidence for competing theoretical rationales?

- *Measuring Brain Activation:* Does the mental process of legal relevance reliably cause identifiable brain changes in individuals, and are these changes measured by the brain scanning technology?

- *False Positives:* By what mechanisms might a particular response produce a false positive result with this technique? What do practitioners of the technique do to counteract or correct for such mechanisms? Is this response to the possibility of false positives reasonable considering the mechanisms involved?

- *False Negatives:* By what means could a particular response produce a false negative result? That is, what is the potential for effective countermeasures? What do practitioners of the technique do to counteract or correct for such phenomena? Is this response to

[69] *Semrau* Ex. 7.

[70] This list is adapted, in some places verbatim, from the visual aids utilized by Dr. Imrey during his testimony. See *Id.*

the possibility of false negatives and effective countermeasures reasonable considering the mechanisms involved?

- *Individual Differences:* Is it possible that measured responses do not always have the same meaning across individuals or that a test that works for some kinds of examinees or situations will fail with others?

- *Social Context:* How do the social context and the social interactions that constitute the examination procedure affect the reliability and validity of the recordings that are obtained?

Brain scans are not presentations of raw data, but are graphical representations of statistical results. Making legally relevant inferences from brain scanning depends, then, on the details of the statistical tools used. Those tools are never perfect, and courts should not expect them to be. But the imperfections should be laid bare, allowing for close and careful examination of the validity of the expert's claims.

5. If group-averaged data were proffered, can one draw from them legitimate inferences about this one individual?

It is an inferential challenge to move from group-averaged neuroscience data to individualized assessments. As David Faigman has put it, "while science attempts to discover the universals hiding among the particulars, trial courts attempt to discover the particulars hiding among the universals."[71] This is a problem courts are familiar with, as it arises routinely in medical causation cases, where courts must distinguish between "general causation" and "specific causation."[72] For example, just because a toxin may, on average in a population, cause an ailment, an individual plaintiff must show that, in his or her specific case, it was the toxin – and not some other factor – that was responsible for the ailment.[73]

---

[71] DAVID L. FAIGMAN, LEGAL ALCHEMY: THE USE AND MISUSE OF SCIENCE IN THE LAW 69 (1999). See also David L. Faigman, *The Limits of Science in the Courtroom, in* BEYOND COMMON SENSE: PSYCHOLOGICAL SCIENCE IN THE COURTROOM 303 (Eugene Borgida & Susan T. Fiske eds., 2008).

[72] David L. Faigman, *Evidentiary Incommensurability: A Preliminary Exploration of the Problem of Reasoning From General Scientific Data to Individualized Legal Decision-Making*, 75 BROOKLYN L. REV. 1137 at 1140 (2010).

[73] *Id.*

By analogy, even if a certain brain activation pattern is, on average in a certain group, caused by a particular mental state, it does not necessarily follow that the brain activation pattern of the specific individual of legal relevance is caused by that particular mental state in the individual. Thus, courts must be cautious in jumping from group averaged data to individual level conclusions.

In *Semrau* the "group to individual" problem was discussed many times in the course of testimony, and was mentioned by Judge Pham in his report. Future cases will surely require courts to similarly evaluate how well researchers have addressed this fundamental inferential problem.

The cognitive neuroscience of individual differences is only now beginning to emerge.[74] And thus courts have a very limited evidence base with which to evaluate individual inferences that are made based on group averaged brain scan studies. While this will surely change in the future, at present courts would be wise to err on the side of caution.

CONCLUSION

The new and improving capacity for non-invasive, functional brain scanning is exciting for the legal system. But, as with any new type of scientific evidence, excitement must be tempered with a series of cautions.

Some of the cautions arise from the general challenges of law/science interactions, which involve efforts to calibrate sensibly between over- and under-inclusion, between over- and under-credulousness, and between legitimate and illegitimate interpretations and applications. Some of the cautions arise from the general gulf between disciplines, one of which must be translated into and understood within the terms and contexts of the other. And some of the cautions arise, as is so frequently the case with new technologies, from challenges unique to themselves, relating to the irreducible details of how this specific set of technologies works.

In this *Symposium* article, we have attempted to provide a quick survey of many of these challenges and to identify and illustrate issues

[74] Ahmad R. Hariri, *The Neurobiology of Individual Differences in Complex Behavioral Traits*, 32 ANNU REV NEUROSCI. 225 (2009). In describing the history of neuroimaging during his testimony, Dr. Raichle noted that "we're beginning to work our way back to getting at individual subjects, but it's challenging because you have far less data to work with to get what you want to get out of it. It's far easier to talk about 33 people that did something than one." *Transcript of Proceedings Vol. II*, supra note 32 at 262.

that courts and litigants will often encounter at this intersection. Neurolaw is not just a fanciful fiction of the future. For better or worse, it is already entering contemporary jurisprudence. And, as *Semrau* illustrates in the brain-based lie detection context, attempts to use brain scans in legal contexts will often precede the full appropriateness of doing so.

Because courts should now anticipate encountering more brain scan evidence sooner rather than later, symposia like the one reported in this volume are essential for fostering the necessary dialogue between neuroscientists, judges, and lawyers that will lay the groundwork for this neurolaw future.[75]

[75] Those interested in following these interdisciplinary developments may wish to subscribe to an email list-serv available through the MacArthur Foundation Law and Neuroscience Project web site: www.lawneuro.org.