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

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I. 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] 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.

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1. For general introductions to law and neuroscience, see Henry Greely & Anthony Wagner, *Reference Guide on Neuroscience, in* FEDERAL JUDICIAL CENTER REFERENCE MANUAL ON SCIENTIFIC EVIDENCE (3d ed., forthcoming 2012); OWEN D. JONES, JEFFREY D. SCHALL & FRANCIS X. SHEN, LAW AND THE BRAIN (forthcoming 2013), *available at* www.http://www.vanderbilt.edu/lawbrain; MACARTHUR PRIMER ON LAW & NEUROSCIENCE (Stephen J. Morse & Adina L. Roskies, eds., forthcoming 2012); Oliver R. Goodenough & Micaela Tucker, *Law and Cognitive Neuroscience*, 6 ANN. REV. L. SOC. SCI. 61 (2010); Owen D. Jones et al., *Brain Imaging for Legal Thinkers: A Guide for the Perplexed*, 2009 STAN. TECH. L. REV. 5; Francis X. Shen, *The Law and Neuroscience Bibliography: Navigating The Emerging Field of Neurolaw*, 38 INT'L. J. LEG. INFORM. 352 (2010); Stacey A. Tovino, *Functional Neuroimaging and the Law: Trends and Directions for Future Scholarship*, 7 AM. J. BIOETHICS 44 (2007). For additional resources, see the home page of the MacArthur Foundation Law and Neuroscience Project at www.lawneuro.org.

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. 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 a 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 such cases, judges and jurors have it hard. It is 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 the use of those scans by discussing the landmark 2010 federal criminal trial *United States v. Semrau*.[2] That case involved the first federal 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 five 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]

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2. No. 07-10074 JPM (W.D. Tenn. June 17, 2010) (PACER). After a thirteen-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 (2006), and not guilty on eleven counts of money laundering and fifty-seven counts of health care fraud. United States v. Semrau, No. 2:10-cr-10074-JPM, 2011 WL 9258, at *1 (W.D. Tenn. Jan. 3, 2011).

3. Judge Pham's Report and Recommendation in *Semrau* ultimately resulted in the exclusion of the evidence on the grounds of Federal Rule of Evidence 702 (testimony by

Still, *Semrau* 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 ready to litigate, whether testimony regarding brain scans should be admitted as evidence for new and controversial purposes.

II. BRAIN SCANS, LIES, AND LAW

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

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 legal circles.[5] Although it

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experts) and Rule 403 (probative value and unfair prejudice). *See* Report and Recommendation, United States v. Semrau, No. 07-10074 M1/P (W.D. Tenn. May 31, 2010). After the Report and Recommendation was submitted on May 31, 2010, the defense filed an objection on June 9, 2010. Defendant's Response to the Government's Motion to Exclude the Usage of GAO Reports, United States v. Semrau, No. 07-10074 M1/P (W.D. Tenn. June 9, 2010). On June 10, 2010, the United States District Court for the Western District of Tennessee adopted the Report and 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, Denying Defendant's Motion for Judgment of Acquittal/to Dismiss and/or Motion for New Trial, and Denying Defendant's Motion to Strike at 67, United States v. Semrau, No. 2:10-cr-10074-JPM (W.D. Tenn. Nov. 23, 2010) [hereinafter Order]. 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 SCI. 1336 (2010); Alexis Madrigal, *Eyewitness Account of 'Watershed' Brain Scan Legal Hearing*, WIRED SCIENCE (May 17, 2010, 7:30 pm), http://www.wired.com/wiredscience/2010/05/fmri-daubert; Greg Miller, *Can Brain Scans Detect Lying? Exclusive New Details From Court Hearing*, SCIENCE MAGAZINE (May 14, 2010, 12:09 pm), http://news.sciencemag.org/scienceinsider/2010/05/can-brain-scans-detect-lying-exc.html; Margaret Talbot, *Brain Scans on Trial*, THE NEW YORKER (May 25, 2010), http://www.newyorker.com/online/blogs/newsdesk/2010/05/brain-scans.htm.

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

5. *See, e.g.*, Giorgio Ganis & Julian Paul Keenan, *The Cognitive Neuroscience of Deception*, 4 SOC. NEUROSCI. 465 (2009). Volume four of Psychology Press's *Social*

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 (EEG), measures electrical activity in the brain.[7] In EEG studies, researchers place 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

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Neuroscience included eight articles, each highlighting a distinct approach to studying the neural correlates of deception. We recommend this volume for lawyers who want a window into the advancing science in this area of deception and neural correlation. Recommended general reviews of neuroscience-based lie detection evidence include EMELIO BIZZI ET AL., USING IMAGING TO IDENTIFY DECEIT: SCIENTIFIC AND ETHICAL QUESTIONS (2009); Anthony Wagner, *Can Neuroscience Identify Lies?, in* A JUDGE'S GUIDE TO NEUROSCIENCE: A CONCISE INTRODUCTION 13 (2010); Archie Alexander, *Functional Magnetic Resonance Imaging Lie Detection: Is a "Brain Storm" Heading Toward the "Gatekeeper"?* 7 HOUS. J. HEALTH L. & POL'Y 1 (2007); Paul S. Appelbaum, *The New Lie Detectors: Neuroscience, Deception, and the Courts*, 58 PSYCHIATRY SERV. 460 (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); Henry T. Greely & Judy Illes, *Neuroscience-Based Lie Detection: The Urgent Need for Regulation*, 33 AM. J. L. & MED. 377, 378-79 (2007); Jane Campbell Moriarty, *Visions of Deception: Neuroimages and the Search For Truth*, 42 AKRON L. REV. 739 (2009); Frederick Schauer, *Can Bad Science Be Good Evidence? Neuroscience, Lie Detection, and Beyond*, 95 CORNELL L. REV. 1191 (2010); Joseph R. Simpson, *Functional MRI Lie Detection: Too Good to be True?* 36 J. AM. ACAD. PSYCHIATRY L. 491 (2008); Kamila E. Sip, et al., *Detecting Deception: The Scope and Limits*, 12 TRENDS IN COGNITIVE SCI. 48 (2007); Paul R. Wolpe et al., *Emerging Neurotechnologies for Lie-Detection: Promises and Perils*, 5 AM. J. BIOETHICS 39 (2005).

6. *See* Ganis & Keenan, *supra* note 5, at 466; 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. *See* Maharashtra v. Sharma, No. 508/07 (Ct. Sess. Pune, India June 12, 2008), http://court.mah.nic.in/courtweb/orders/pundcis/orders/201501005082007_1. pdf. In 2010, however, the Supreme Court of India ruled that compulsory administration of such evidence–narco analysis, brain mapping, and polygraph tests–violates Article 20(3) of the Constitution of India, INDIA CONST. art. 20(3), which protects the right to silence, and Article 21, INDIA CONST. art. 21, which guarantees the right to privacy and substantive due process. Selvi v. Karnataka, No. 1267 of 2004, at *246-49 (India May 5, 2010), http://judis.nic.in/supremecourt/helddis.aspx.

8. At least one United States 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. Greely & Illes, *supra* note 5, at 387-88.

detectable patterns in the electrical signals in a person's brain–when that person is lying.[9]

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

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 factors include the experimental design (the paradigm used and the specific set of tasks), proper execution of the design, and proper interpretation of the results. A number of paradigms, across many different labs, have been employed to date. These paradigms include the following: (1) forced-choice lies (for example, responding "yes" when the truth is "no" and vice-versa), (2) spontaneous lies (for example, saying "Chicago" when the true answer is "Seattle"), (3) rehearsed and 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).[12]

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. This question immediately subdivides, however, according to context.

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9. On developments in this technique, see J. Peter Rosenfeld, *'Brain Fingerprinting': A Critical Analysis*, 4 SCI. REV. MENTAL HEALTH PRAC. 20 (2005); J. Peter Rosenfeld et al., *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 a 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, *supra* note 5, at 3.

11. Jones, *supra* note 1, ¶ 17.

12. For a more detailed description of the experimental paradigms used, see Simpson, *supra* note 5, at 492-93; Sip et al., *supra* note 5, at Table 1.

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).[13] 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 particular subject was lying on a particular question.

The scientific literature reflects a fairly broad 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."[14]

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. The law's concern is whether the techniques are meaningfully better than the next best alternative technique currently deployed in the legal process,[15] 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:

· A past act or experience (e.g., I was not at the scene of the crime)

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13. 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).

14. Wagner, *supra* note 5, at 14. Wagner identified and reviewed twenty-eight relevant "peer reviewed publications reporting unique fMRI or PET data sets that examine brain responses during putative 'deception versus truth telling.'" *Id*. at 13. 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 "[i]n the case of lie detection 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 et al., *supra* note 5, at 50. 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'Y LOND. B 1697 (2004).

15. *See* Jones, *Law, Evolution and the Brain, supra* note 14, at 1700-01; Schauer, *supra* note 5, at 1191.

· 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).[16]

Each of these permutes with a particular legal setting (such as a sentencing hearing, parole hearing, or 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 experimental paradigm, applied to a particular question of legal relevance. We illustrate in the next Part.

III. UNITED STATES V. SEMRAU

A. Background

In *United States v. Semrau*, the government charged psychologist Dr. Lorne Semrau with Medicare/Medicaid fraud. Proving fraud required proving that Semrau knowingly violated the law. Semrau's defense was partly built 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 incorrectly billed for services, he did not do so intending to commit fraud. Semrau owned two businesses, each of which contracted with nursing homes in Tennessee and Mississippi to provide 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

16. 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 "[g]iven 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, such as interrogation, police investigations, settlement negotiations, and so on.

had manipulated Medicare and Medicaid billing codes to inflate payments, resulting in $3 million worth of fraud.[17]

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"?[18] To bolster Semrau's credibility in asserting that he had not knowingly engaged in prohibited billing practices, defense attorney Houston Gordon contacted Dr. Stephen Laken, founder and CEO of Cephos Corporation.[19] 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 Gordon to develop a set of Specific Incident Questions (SIQs) that Dr. Semrau would answer in the scanner.[20] The questions[21] included, "Did you bill CPT Code 99312 to cheat or defraud

17. Report and Recommendation, *supra* note 3, at 3-5; United States Attorney's Office for the Western District of Tennessee, *Federal Jury Convicts Psychologist for False Billings to Medicare/Medicaid*, FED. BUREAU OF INVESTIGATION: MEMPHIS (June 28, 2010), http://memphis.fbi.gov/dojpressrel/pressrel10/me062810.htm. The Government alleged that "[t]o 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 3, at 4.

18. Report and Recommendation, *supra* note 3, at 5 (internal quotation marks omitted). 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 argued "that his actions were reasonable under the circumstances because the CPT codes were confusing and unclear, and claim[ed] he followed instructions and guidance provided by CIGNA and CAHABA representatives." *Id.* 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 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 Volume IV at 63, United States v. Semrau, No.: 07CR10074-1-JPM (W.D. Tenn. May 14, 2010).

19. Report and Recommendation, *supra* note 3, at 6, 10-11. Cephos's website may be found at http://www.cephoscorp.com/.

20. Report and Recommendation, *supra* note 3, at 6, 10-11. Question development involved rehearsal with Semrau himself. *See* Transcript of Proceedings Volume I at 68, United States v. Semrau, No. 07-cr-10774 (W.D. Tenn. May 13, 2010).

21. In this case, Laken and Gordon 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 Volume I, *supra* note 20, at 93-94. Dr. Laken readily admitted on the stand that this overall statement did not allow him to assess truthfulness on any one of the

Medicare?" and "Did you enter into a scheme to defraud the government by billing for AIMS tests conducted by psychiatrists under CPT Code 99301?"[22] Neutral questions, against which the answers to SIQs would be compared, were also used.[23] Examples of neutral questions included, "Do you like to swim?" and "Are you over age 18?"[24] The defense and Laken co-designed the tasks and the SIQs without the knowledge of the prosecution (a fact that would later factor into the court's analysis).[25]

On December 30, 2009, Semrau traveled to the Cephos office in Framingham, Massachusetts, for his initial brain scanning session.[26] Following data analysis, Laken made two conclusions. First, as to whether Semrau was being honest when he claimed that he had not knowingly defrauded the government, Laken concluded that "[i]t appeared his brain showed that he was telling the truth." Second, as to whether 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."[27] This second conclusion was obviously not the result Semrau's defense team wanted.

After analyzing the data further, Laken contacted 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.[28] 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."[29]

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

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questions individually. *Id.* at 137-40.

22. Report and Recommendation, *supra* note 3, at 12-13.

23. Transcript of Proceedings Volume I, *supra* note 20, 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. *Id*.

24. Report and Recommendation, *supra* note 3, at 11 (internal quotation marks omitted).

25. *Id*.

26. *Id*. at 14.

27. Transcript of Proceedings Volume I, *supra* note 20, at 95.

28. *Id*. at 96, 152. Laken admitted that fatigue could have made the first scan inaccurate too. *Id*. at 152.

29. *Id.* at 97.

testify about the truthfulness of Semrau's claim in *December 2009 and January 2010*, concerning his state of mind between 1999 and 2005.[30] As Laken stated, "What we can say is . . . he believes that he is telling the truth."[31]

Verifying the truthfulness of a belief, of course, doesn't provide the court with information on so-called "ground truth"–that is, 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.*"[32] 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.[33]

B. The Admissibility of the Evidence

On May 13 and 14, 2010, United States Magistrate Judge Tu Pham conducted a hearing on whether the brain-based lie detection evidence should, at a later date, be heard by the empanelled jury.[34] 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.[35]

Judge Pham considered both the relevance of Laken's proferred testimony, under Rule 702 of the Federal Rules of Evidence, and its probative value, under Rule 403. In applying Rule 702, federal courts perform a two-prong gatekeeping role for expert scientific evidence by first evaluating the reliability and then the relevance of the testimo-

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30. Report and Recommendation, *supra* note 3, at 19 n.15.

31. Transcript of Proceedings Volume I, *supra* note 20, at 99.

32. *Id.* at 70-71 (emphasis added).

33. 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 truthfulness. Transcript of Proceedings Volume II at 237, United States v. Semrau, No. 07-cr-10774 (W.D. Tenn. May 13, 2010).

34. 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 of the United States 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*, 62 MERCER L. REV. 959 (2011). For a more general discussion, see DAVID L. FAIGMAN ET AL., MODERN SCIENTIFIC EVIDENCE: THE LAW AND SCIENCE OF EXPERT TESTIMONY (2010-2011 ed. 2010).

35. Disclosure: both of these witnesses are known to the Authors as colleagues within the MacArthur Foundation Law and Neuroscience Project.

ny.[36] 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:

> (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.[37]

Judge Pham found that factors one and two were satisfied, while factors three and four were not.[38] Judge Pham concluded that "at least at this early stage in its development, fMRI-based lie detection does not satisfy the requirements of Rule 702."[39]

Judge Pham's Report and Recommendation was, in our view, thorough, well reasoned, and correct in its conclusions on each of these four factors.[40] There was relatively little dispute that the theory and technique presented by Laken had indeed been tested, and that the defense won on the issue of peer review.[41]

As to whether the error rates are known, however, the defense arguments were not as strong. Analogizing to a polygraph case from the United States Court of Appeals for the Ninth Circuit, *United States v.*

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36. FED. R. EVID. 702; *see also Daubert*, 509 U.S. 579.

37. *Id.* at 22 (citing *Daubert*, 509 U.S. at 593-94; First Tenn. Bank Nat'l Ass'n v. Barreto, 268 F.3d 319, 334 (6th Cir. 2001)).

38. *Id*. at 24-33. 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).

39. Report and Recommendation, *supra* note 3, at 25.

40. Judge John McCalla held the same view when evaluating the defense's motion for a new trial. *See* Order, *supra* note 3. One of the arguments for a new trial was the exclusion of the lie detection evidence, but Judge McCalla found that the testimony was properly excluded on both Rule 702 and Rule 403 grounds. *Id*.

41. *See* Report and Recommendation, *supra* note 3, at 25-26. In a single paragraph in the Report and Recommendation, 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.

Id.

Cordoba,[42] Judge Pham ruled that "[h]ere, like in *Cordoba*, the error rate of real-life fMRI-based lie detection is unknown."[43] Moreover, Judge Pham was troubled by Laken's choice to do a third brain-scan test (following an uncomfortable finding), when the protocol had only called for two.[44] Judge Pham observed that Laken's "decision to conduct a third test begs the question whether a fourth scan would have revealed Dr. Semrau to be deceptive again."[45] Judge Pham found that "lack of controlling standards in the industry for real-life exams, and Dr. Laken's apparent deviation from his own protocols are negative factors in the analysis of whether fMRI-based lie detection is scientifically valid."[46]

On the issue of general acceptance, the defense argued that in the United States Court of Appeals for the Sixth Circuit, "general acceptance within a particular scientific community does not mean unanimity or consensus."[47] The Government countered that scholars viewed neuroscience lie detection generally, and Cephos's technology in particular, as not ready for courtroom use.[48] Judge Pham was persuaded and in his Report and Recommendation quoted several scholarly articles to support his conclusion that "[n]o doubt in part because of its recent development, fMRI-based lie detection has not yet been accepted by the scientific community."[49]

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."[50] This was due in part to the fact that the fMRI test was obtained unilaterally.[51] Judge Pham also emphasized that because of the inability of the Cephos tests

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42. 194 F.3d 1053 (9th Cir. 1999).

43. Report and Recommendation, *supra* note 3, at 28.

44. *Id.* at 31-32.

45. *Id.* at 32.

46. *Id.*

47. Transcript of Proceedings Volume I, *supra* note 20, at 9.

48. Supplement 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, United States v. Semrau, No. 07-10074-M1 (W.D. Tenn. Mar. 24, 2010) [hereinafter Supplement].

49. Report and Recommendation, *supra* note 3, at 32-33.

50. *Id*. at 34. In making its 403 ruling, the court relied on *United States v. Sherlin*, 67 F.3d 1208 (6th Cir. 1995), and *United States v. Thomas*, 167 F.3d 299 (6th Cir. 1999). Report and Recommendation, *supra* note 3, at 34.

51. Report and Recommendation, *supra* note 3, at 34. Judge Pham observed, "While the Sixth Circuit . . . 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." *Id*.

to provide the court with information on Semrau's truthfulness on particular questions (and not just overall), exclusion under Rule 402 was "particularly appropriate."[52] Indeed, during Dr. Laken's cross-examination by U.S. Attorney Stuart Canale, Dr. Laken readily admitted that it was *possible that Semrau might have been lying* on some of the specific incident questions.[53] In addition, the Government, citing *United States v. Scheffer*,[54] argued that "[i]t is simply infringing on the province of the jury to make the ultimate credibility determination of testimony."[55]

Despite their many disagreements, Judge Pham and both sides agreed that the neuroscience in this area is fluid and that someday the science might advance enough to pass the *Daubert* test. As Judge Pham explained,

> [I]n 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.[56]

Brain-based lie detection evidence may also arise in legal contexts quite different from *Semrau*, in which evidentiary rules and substantive issues will require distinct analyses.[57] We should also remember that legal change might come from legislative action rather than a judge's

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52. *Id*. at 38. The court reasoned that "[b]ased 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." *Id.*

53. Transcript of Proceedings Volume I, *supra* note 20, at 138. The court thus 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 and Recommendation, *supra* note 3, at 33.

54. 523 U.S. 303 (1998).

55. Transcript of Proceedings Volume I, *supra* note 20, at 12-13. As Justice Thomas wrote in *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.'" 523 U.S. at 313 (quoting United States v. Barnard, 490 F.2d 907, 912 (9th Cir. 1973)). "Determining the weight and credibility of witness 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." *Id*. (alteration in original) (quoting Aetna Life Ins. Co. v. Ward, 140 U.S. 76, 88 (1891)) (internal quotation marks omitted).

56. Report and Recommendation, *supra* note 3, at 31 n.18.

57. Indeed, the summer of 2010 also saw an attempt in New York to introduce similar evidence. *See* Wilson v. Corestaff, 900 N.Y. S.2d 639, 640, 642 (Sup. Ct. 2010). During his testimony, Dr. Laken also referenced testifying in a South Carolina post-conviction relief case. Transcript of Proceedings Volume I, *supra* note 20, at 119-20.

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.[58]

IV. FIVE ISSUES AFFECTING ADMISSIBILITY

The analysis of admissibility of brain-scanning evidence in *United States v. Semrau* was relatively straightforward in the end. A close study of the case and transcript, however, in light of the brain-based lie detection literature to date, suggests there are a number of broader issues that will–or at least should–emerge when courts consider the admissibility of testimony regarding brain scans. Here we identify, and then briefly explain, five of 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

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58. In 2009 New York Assemblyman Michael Benjamin proposed bill A9154: "An act to amend the criminal procedure law, in relation to admissibility of magnetic resonance imaging (MRI) brain scans in criminal proceedings." H.R. A9154, 2009 Assemb., Reg. Sess. (N.Y. 2009) (unenacted). The stated purpose of the bill was "[t]o 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." Michael Benjamin, *New York State Assembly: Memorandum in Support of Legislation*, N.Y. STATE LEGISLATURE (Sept. 22, 2009), http://public.leginfo.state.ny.us.

significant findings may advance a scientific field but can only be as legally meaningful as the legal appropriateness of the experimental protocols allows. 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.[59] It is not clear whether, when using an instructed lie paradigm, courts can draw credible inferences about real world "lying."

Neuroscientist Nancy Kanwisher 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.'"[60] Neuroscientist Kamila E. Sip and her colleagues similarly argue that "[t]he absence of this intentional aspect of deception in the experiments is . . . more than a mere experimental confound."[61] 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*.[62]

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 do not

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59. *See, e.g.*, Sip et al., *supra* note 5.

60. Nancy Kanwisher, *The Use of fMRI in Lie Detection: What Has Been Shown and What Has Not, in* USING IMAGING TO IDENTIFY DECEIT, *supra* note 5, at 7, 12.

61. Sip et al., *supra* note 5, at 48.

62. 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. Transcript of Proceedings Volume I, *supra* note 20, at 159. Instructed lies, in Laken's view, are real lies. *Id*. Because this view is contested, however, courts must be attuned to what researchers are telling subjects to do in the fMRI scanner. When this question comes up in future litigation, new research may address these issues. This is a problem that can be corrected through improved experimental paradigms. *See* 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 13.

yet know how rehearsal of a lie over time involving activation of memory systems affects brain chemistry.[63] Until we better understand the 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. In other words, researchers may not have isolated the particular system they claim to have isolated.[64] 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 cause 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?

Courts want to know how useful proferred evidence may be to resolving a contested legal issue. Consequently, when encountering brain-scan evidence, courts will want to approach questions of admissibility 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

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63. 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 20. 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 (2002); Nobuhito Abe et al., *Neural Correlates of True Memory, False Memory, and Deception*, 18 CEREBRAL CORTEX 2811 (2008); Elizabeth F. Loftus, *Planting Misinformation in the Human Mind: A 30-Year Investigation of the Malleability Of Memory,* 12 LEARNING & MEMORY 361 (2005).

64. 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 Volume II, *supra* note 33, at 265. Dr. Raichle later made a similar point: "[T]his 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." *Id.* at 312.

correlate positively with high external validity, this is not always the case and, therefore, the two issues should both be considered.[65] 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.[66] In *Semrau,* when Dr. Laken was asked on cross-examination about ecological validity, he replied,

> 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.[67]

This statement reflects an assumption that a lie–whether told in a scanner without consequence or in the real world with great consequence–should always be expected to activate the same brain regions. While theoretically plausible, such an assumption is not generally accepted.

As to external validity in *Semrau*, the Government pointed out that although the algorithm developed by Laken was created from laboratory studies of subjects between the ages of eighteen and fifty, Semrau was sixty-three.[68] This raised the question whether fMRI results from younger cohorts could validly serve as reference points for someone considerably older. During cross-examination, Assistant United States Attorney Canale hit upon this age effect, asking 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."[69]

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65. 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.

66. *See* Wagner, *supra* note 5, at 22. Neuroscientist Elizabeth Phelps argues,

> 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 A. Phelps, *Lying Outside the Laboratory: The Impact of Imagery and Emotion on the Neural Circuitry of Lie Detection, in* USING IMAGING TO IDENTIFY DECEIT, *supra* note 5, at 14, 20.

67. Transcript of Proceedings Volume IV, *supra* note 18, at 39-40.

68. *Id.* at 66.

69. Transcript of Proceedings Volume II, *supra* note 33, at 190.

Judge Pham cited this exchange in a footnote in his Report and Recommendation,[70] and we expect that concerns about external validity will be a part of every attempt to introduce neuroscience based lie detection evidence.

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 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 fMRI scanner because movement during scan acquisition may make the resulting data unusable.[71] 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–for example, wanting to get through the experiment as quickly as possible by clicking a response button and not carefully listening to directions. A subject may, however, intentionally engage in countermeasures by behaving in the scanner in a way that is antithetical to the instructions given. Thus, when encountering brain-based evidence, courts must consider how readily the researchers could have detected non-compliance with their instructions.

Lie detection provides a clear illustration of this general point. In its review of the polygraph, a National Academies expert panel found that "[c]ountermeasures 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

70. Report and Recommendation, *supra* note 3, at 29 n.17.

71. Cameron S. Carter et al., *Optimizing the Design and Analysis of Clinical Functional Magnetic Resonance Imaging Research Studies*, 64 BIOLOGICAL PSYCHIATRY 842, 845 (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).

physical means."[72] The same concerns should be raised about brain-based lie detection because we simply don't know enough about the potential effectiveness of fMRI countermeasures.[73]

Courts will be confronted with the question of whether fMRI lie detection is analogous to–or distinguishable from–its polygraph precursor. In the words of attorney Houston Gordon, the defense in *Semrau* claimed that, unlike an individual who can alter his polygraph test, in a brain scanner a subject "can't manipulate his brain."[74] The Government disagreed, and the court rightly analogized in this case to the polygraph.[75] As the science of brain-based lie detection techniques advances, however, courts will need to revisit the polygraph analogy question.

Beyond the lie detection context, courts must also be aware not only of all other subject-specific behavior in the scanner–for example, movement or failure to comprehend instructions–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 a brain-scanning device into a graphical image displayed in court.[76] Thus, there are a correspondingly large number

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72. NATIONAL RESEARCH COUNCIL, *supra* note 4, at 4.

73. Greely & Illes, *supra* note 5, at 404-05.

74. Transcript of Proceedings Volume IV, *supra* note 18, 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 Volume II, *supra* note 33, at 240-41. 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 Volume IV, *supra* note 18, at 64-65.

75. *See Semrau*, No. 07-10074 JPM.

76. For an introduction to the types of statistical procedures used, see Jones et al., *supra* note 1.

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 an analysis, as well as the statistical uncertainty of the researcher's conclusions.[77] In short, courts need to understand the validity of the statistical analyses producing the brain images and their interpretation.

To illustrate using *Semrau*, biostatistician 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 a generalization to contexts outside the specific.[78] 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 the following questions–adapted from concerns raised by Imrey in *Semrau*–about the procedures used to produce and analyze the brain data.[79]

> **1. Theoretical Rationale.** 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?"
>
> **2. 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?
>
> **3. 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

77. 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 CENTER REFERENCE MANUAL ON SCIENTIFIC EVIDENCE 83 (2d ed. 2000).

78. Transcript of Proceedings Volume III at 355-56, United States v. Semrau, No. 07-cr-10774 (W.D. Tenn. May 13, 2010).

79. This list is adapted, in some places verbatim, from the visual aids utilized by Dr. Imrey during his testimony. *See* Exhibit 7, United States v. Semrau, No. 07-cr-10774, at 23-27 (W.D. Tenn. May 13, 2010).

such mechanisms? Is this response to the possibility of false positives reasonable considering the mechanisms involved?"

4. False Negatives. How "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 the possibility of false negatives and effective countermeasures reasonable considering the mechanisms involved?"

5. 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?"

6. 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. The imperfections should be laid bare, however, 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, "[w]hile science attempts to discover the universals hiding among the particulars, trial courts attempt to discover the particulars hiding among the universals."[80] This is a problem courts are familiar with, as it arises routinely in medical causation cases in which courts must distinguish between general causation and specific causation.[81] For example, the fact that an ailment is often caused, in the general

80. 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).

81. David L. Faigman, *Evidentiary Incommensurability: A Preliminary Exploration of the Problem of Reasoning from General Scientific Data to Individualized Legal Decision-Making*, 75 BROOK. L. REV. 1115, 1119, 1131 (2010).

population, by a particular toxin doesn't relieve an individual plaintiff who has that ailment from having to demonstrate that in his specific case it was that particular toxin–and not some other substance–that most likely caused his ailment.[82]

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 and Recommendation.[83] Future cases will similarly require courts to evaluate how well researchers have addressed this fundamental inferential problem.

The cognitive neuroscience of individual differences is only now beginning to emerge.[84] 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.

V. CONCLUSION

The new and improving capacity for non-invasive, functional brain scanning is exciting for the legal system. As with any new type of scientific evidence, however, 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, over- and under-credulousness, and 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.

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82. *Id.* at 1119.

83. Report and Recommendation, *supra* note 3, at 26 n.16.

84. *See, e.g.*, Ahmad R. Hariri, *The Neurobiology of Individual Differences in Complex Behavioral Traits*, 32 ANN. 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 Volume II, *supra* note 33, at 262.

In this Article, we have attempted to provide a quick survey of many of these challenges and to identify and illustrate issues 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. As *United States v. 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 anticipate encountering brain-scan evidence sooner rather than later, symposia like the one reported in this Volume of the *Mercer Law Review* are essential for fostering the necessary dialogue between neuroscientists, judges, and lawyers that will lay the groundwork for this neurolaw future.[85]

85. 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 website at www.lawneuro.org.