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FUNCTIONAL MAGNETIC RESONANCE IMAGING LIE DETECTION: IS A "BRAINSTORM" HEADING TOWARD THE "GATEKEEPER"?

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I. INTRODUCTION

"And God spake all these words, saying I am the Lord thy God . . . Thou shalt not bear false witness against thy neighbor."[1]

Clearly, God, in His Ten Commandants to the Hebrew nation, served notice that truth telling was important, and His Commandments set the tone for much of the civilized world for centuries to come. Throughout time, man has also recognized the importance of telling the truth.[2] Many well-known historical figures and political advisors, such as Niccolò Machiavelli, appreciated the importance of truth telling in human interactions.[3] Machiavelli often counseled his rulers that a wise ruler should seek advice from those who

[1] *Exodus* 20:16 (King James).

[2] *See* Sean A. Spence et al., *A Cognitive Neurobiological Account of Deception: Evidence from Functional Neuroimaging*, 359 PHILOSOPHICAL TRANSACTIONS ROYAL SOC. B 1755, 1755–56 (2004) [hereinafter Spence et al., *Cognitive Neurobiological*].

[3] *See id.* at 1755.

would tell them the truth.[4] Machiavelli also realized the necessity of prevarication during political interactions, because he further advised them to use deception against their political rivals.[5] History is filled with celebrated examples of the effectiveness of deception and its ability to change the course of human events.

Perhaps the most celebrated example of the pivotal role deception can play in history comes from the Greek conquest of Troy, where a clever subterfuge allowed a bitter foe to destroy the population of its rival.[6] The Greeks and Trojans had fought a savage conflict over the Trojan city of Troy for years that virtually ended in a stalemate. The Greek king, Odysseus, and his fellow soldiers turned the tide of the war with a single, decisive maneuver that successfully employed deception.[7] He tricked the Trojans into believing that the Greek army had fled the gates of Troy for Greece.[8] Meanwhile, the Greeks concealed themselves within the now famous Trojan horse.[9] Although the deception worked flawlessly, the deception would not have succeeded had it not been for one lone Greek named Sinon who volunteered to stay behind to complete their deception.[10] Not only did Sinon convince the Trojans that he had abandoned the Greeks, but he also deceived them when he told them that the horse was a gift of good luck from the Greeks.[11] The Trojans were so completely duped by his ruse that they moved the Trojan horse into their city.[12] Unfortunately for the Trojans, their failure to detect Sinon's deception cost them their lives and their city.[13] Yes,

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4 HARVEY C. MANSFIELD, THE PRINCE 95 (2nd ed. Univ. Chicago Press 1998).

5 *See* Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1756 (quoting Machiavelli as having said "[O]ne must know how to colour one's actions and to be a great liar and deceiver. Men are so simple, and so much creatures of circumstance, that the deceiver will always find someone ready to be deceived.").

6 *The Trojan War*, http://www.stanford.edu/~plomio/history.html (last visited Apr. 13, 2006).

7 *Id*.

8 *Id*.

9 *Id.* (describing the tactical deception utilized by Odysseus, with the aid of Athena some say, to dupe the Trojan into believing that the Greek forces had departed from Troy, and to trick the Trojans into opening the gates of Troy to take in a wooden horse containing Odysseus and his fellow Greek soldiers).

10 *Id*.

11 *Id*.

12 *The Trojan War*, *supra* note 6 (explaining how Sinon was left by the Greeks to convince the Trojans that the Greeks had left, the Trojan horse was safe, and he was their friend; but the Trojans soon learned he was no friend when he released his comrades from the Trojan Horse, and they slew the Trojans as they slept in their drunken state).

13 *Id.*

deceptions, if undetected, can lead to disastrous outcomes for the unwary or unwise victim.

Not only has deception determined the outcome of major battles and toppled civilizations, but it also has led to disastrous results for individual political leaders who failed to use it wisely. Perhaps one of the most celebrated examples of the misuse of deception occurred during the Nixon administration in the early 1970s, when it tried to avoid a political scandal by characterizing a break-in, committed as part of its attempt to collect politically damaging information on one of its opponents, as a third-rate burglary.[14] Unfortunately, neither President Nixon nor his cohorts were able to successfully keep the truth from Congress or the American people. The political scandal and fallout that followed from their failed deception forced Nixon to resign in disgrace.[15] Even today, the elusive search for the truth creates peril for its seekers, who go too far in their quest for the truth. Just ask members of the Department of Defense (DOD) who became embroiled in a scandal after they were accused of torturing prisoners to gain information in their Global War on Terrorism.[16]

More often than not, truth seekers are not only incapable of detecting deception, but they are also unable to ascertain the truth. Throughout time, societies have given various individuals the responsibility for detecting deceivers, and their governments have sought methods to assist them in their attempts to detect deception. Some of these methods have been quite crude, while others represent nothing more than sophisticated applications of psychological force or physical torture to extract the truth.[17] Some cultures, for example, have relied on crude physiological signs of deception, such as the lack of saliva that might occur in a nervous liar who is forced to chew on bread while answering questions—the guilty are said to "lack a production of saliva."[18] Still other cultures may ap-

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[14] *See Political Scandals of the United States*, WIKIPEDIA, http://en.wikipedia.org/wiki/Political_scandals_of_the_United_States (last visited Jan. 15, 2007).

[15] *See id.*

[16] Sean Kevin Thompson, *The Legality of the Use of Psychiatric Neuroimaging Intelligence Interrogation*, 90 CORNELL L. REV. 1601, 1602 (2005) (discussing efforts by the Department of Defense to seek out and develop new technologies that will enable it to detect deception on the part of a suspect).

[17] *See* Jack S. Annon, *Detection of Deception and Search for Truth: A Proposed Model with Particular Reference to the Witness, the Victim, and the Defendant*, 1 FORENSIC REPORTS 303, 323 (1987).

[18] *See id*. (explaining that the Chinese and Arabic cultures use food to indicate the "lack of saliva" in the mouth of the witness, which they associated with fear on the part of a person attempting to deceive her examiner).

peal to the judgment of God through a "trial by combat," where adversarial parties could demonstrate their truth telling abilities by vanquishing a perjured foe during a duel to the death.[19] Still other societies, such as those in medieval Europe, utilized the skill of their engineers and scientists to fashion torture machines, such as the rack and thumbscrew, to extract confessions from uncooperative defendants.[20] Many European governments practiced the art of torture for the extraction of truth from the unwilling into the 1900s.[21] Conversely, countries such as England abandoned the use of torture, as an investigative tool, toward the end of the eighteenth century because the English people did not consider it a practice worthy of their civilized society.[22]

Surprisingly, some modern countries continue to push the edge of the envelope in their application of psychological or physical force during their interrogation techniques.[23] In fact, the U.S. government may serve as the most recent example of a political entity running amuck with its interrogation practices during its Global War on Terrorism.[24] It should be no surprise that civilized countries, such as the U.S., and the legal systems that support them, generally prefer not to be associated with any practice that could be classified as torture.[25] Understandably, governments of most civilized nations, including the U.S., turn to their scientists and technology to help

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19 *See* JOHN H. LANGBEIN, TORTURE AND THE LAW OF PROOF (Univ. of Chicago Press 1976) (discussing the applications of the medieval torture machines employed by European justice systems).

20 *See id.*

21 *Id*.

22 *See* A (FC) v. Sec'y of State for the Home Dep't, [2005] UKHL 71, [2005] 3 A.C. 68, 71 (appeal taken from Wales) (U.K.), *available at* http://www.parliment.thestationaryoffice.co.uk/ pa/200506/ldjudgment/jd/o51208/aand.pdf (explaining in dicta the origins in English common law for the prohibition against torture where most European states used torture to obtain confessions in order to satisfy the strict standards of proof needed by their Roman-canon models of law they had adopted).

23 *Torture Hotel*, HARPER'S MAG. (last visited Jan. 6, 2007), *available at* http://www.harpers.org/Torture.html (detailing the history of torture utilized by governments, for example, the Israeli security forces were accused of torturing Palestinian prisoners to extract information during the 90s, and since 2000, according to Amnesty International, its use in interrogation is increasing world wide).

24 *See Torture: Quick Facts*, HUMAN RIGHTS FIRST, *available at* http://humanrightsfirst.org/us_law/etn/misc/factsheet.htm (last visited Apr. 12, 2006) (citing multiple alleged facts regarding the practice of torture by the U.S. in its Global War on Terrorism).

25 *See* A (FC) v. Sec'y of State for the Home Dep't, [2005] UKHL 71, [2005] 3 A.C. 68, 71 (appeal taken from Wales) (U.K.) (discussing the role of torture in English history).

them extract the truth in order to avoid political scandals resulting in public revulsion to torturing people.[26]

The science of "deception" detection began in earnest in the 1800's, when scientists started developing deception tests based on detectable alterations in human physiology related to the fear of being caught.[27] Most early tests, such as the "systolic blood pressure deception test" developed by William Marston in 1938, which is considered the forerunner of the modern polygraph, focused on the measurement of changes in blood pressure.[28] With each advance in the understanding of the human stress response, additional tests, such as the voice stress analyzer and plethysmograph, were invented to detect the stress associated with deception.[29] Not only have scientists utilized technology to detect deception, but they also have brought pharmacology into the interrogation process by administering drugs to keep the higher executive functions from monitoring deception and blocking truth telling.[30] Still others have sought to use the power of the mind to assist forensic investigations by hypnotizing subjects in order to hypnotically refresh their memories.[31] Even so, these methods may not provide governments and their legal systems with the quality of answers they seek; so the search for more sophisticated tests continues.[32]

Perhaps some governments may be hoping that their scientists will discover the truth-telling capabilities of the magic lasso possessed by 1940s comic strip character Wonder Woman, who was

[26] *See Torture Hotel*, *supra* note 23.

[27] Annon, *supra* note 11, at 623–25 (reviewing the various physiologic techniques that focused on detecting fear responses in the brain, such as the measurement of blood pressure test by Angelo Mosso in the mid–1800s, the application of the blood pressure test to criminal interrogations by Cesare Lombroso at the end of the 1800's, the creation of word association tests created by Francis Galton in 1879, the recordation of physiological changes associated with deception by Hugo Münsterberg in 1908, the use of respiratory patterns to detect deception by Vittorio Benussi in 1913, the systolic blood pressure "deception test" developed by William Marston, and the addition of the skin galvanic response measurement to the systolic blood pressure test by Leoanarde Keeler in 1938).

[28] *See id*. at 326.

[29] *See id.* at 329.

[30] *See id*. at 332.

[31] Daniel R. Webert, Note, *Are the Courts in a Trance? Approaches to the Admissibility of Hypnotically Enhanced Witness Testimony in Light of Empirical Evidence*, 40 AM. CRIM. L. REV. 1301, 1301–02 (2003) (noting that the technique of hypnosis has been employed by investigators to help witnesses remember events surrounding a crime or other events).

[32] *See* Sean Kevin Thompson, *The Legality of the Use of Psychiatric Neuroimaging in Intelligence Interrogation*, 90 CORNELL L. REV. 1601–02 (2005) (discussing the obsolescence of torture techniques and the need by the Department of Defense to develop new techniques).

also created by William Marston.[33] Yes, it is the same Marston who helped develop the forerunner of the modern polygraph machine.[34] Some governments may be searching for high tech gizmos, such as electrical impulse detectors and retinal scanners shown in the Hollywood movies *Brainstorm*[35] and *Blade Runner*,[36] respectively.

In *Brainstorm*, for example, the protagonist of the movie develops a helmet that can sense electrical impulses emitted from the brain that are reprocessed by a computer, translating them into visible images of human thought.[37] Of course, the military commandeered the device, once they understood the true potential for thought analysis, prompting the good scientists to eventually destroy it.[38] For the science of the time, such a machine would seem pretty far-fetched, but the technological advances in neuroimaging of the 21st century may be rapidly achieving their dream.

One such futuristic deception detection device currently under study by the DOD is similar to the one depicted in *Brainstorm*. This brain fingerprint detection device detects electrical impulses with the aid of a computer and an electroencephalogram, which detect P300 brain waves or Memory-and-Encoding-Related-Multifaceted-Electroencephalographic-Response (MERMER) emitted from the human brain.[39] Believe it or not, the parallelism between brain fingerprinting technology and the helmet detection device in the movie *Brainstorm* is striking. Both rely on an array of sensor elec-

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[33] *Wonder Woman*, WIKIPEDIA, http://en.wikipedia.org/wiki/Wonder_Woman (last visited Jan. 15, 2007) (recounting the life and times of the comic book character Wonder Woman who was from a mythical race of Amazon women, which gave her many magical powers in the mortal world, but one of her powers, the ability to control people and to make them tell the truth came from her magic lasso).

[34] *Id.*

[35] BRAINSTORM (Warner Bros. Pictures 1981) (opening of this 1981 science-fiction film wowed audiences with its special effects associated with a virtual reality system that could send sensory inputs into the brain as well as record sights, sounds, feelings, and even dreams of a person).

[36] BLADE RUNNER (Warner Bros. Pictures 1982) (stunning science-fiction movie set in the year 2019 about humanoid androids being tracked by ex-detective Harrison Ford, who used a retinal scanner to detect changes in pupillary responses of the eye of a "replicant" when it was asked questions that caused it be agitated or deceptive).

[37] *See* BRAINSTORM, *supra* note 35.

[38] *See id*.

[39] Andre A. Moenssens, *Brain Fingerprinting—Can It Be Used to Detect the Innocence of Persons Charged with a Crime?*, 70 UMKC L. REV. 891, 893–98 (2002) (describing the scientific and technological principles of brain fingerprinting that grew out of the discovery of the EEG recordings of the P300 brain wave that represents a Memory-and-Encoding-Related-Multifaceted-Electroencephlographic Response or MERMER, which represents a memory response to a stimulus).

trodes inside, which are connected to a recorder and a computer.[40] Both of these devices detect brain waves and both possess potential military applications. In fact, the DOD initially envisioned deployment of brain fingerprinting technology in its counter-terrorism campaign.[41] It saw brain fingerprinting technology as a potentially useful weapon for detecting the memory tracings of individuals, who might have been involved in terrorist-related events.[42]

More recently, both civilian and DOD investigators have focused on neuroimaging techniques, such as Positron Emission Tomography (PET) imaging, Single Photon Emission Computed Tomography (SPECT) imaging, and Functional Magnetic Resonance Imaging (fMRI), to image the brain and the regions of the brain that may be activated during the process of deception.[43] Of these three neuroimaging technologies, fMRI has generated the most excitement and controversy because of its ability to image or detect brain function during deception.[44] Not only has the use of fMRI deception detection practices raised neuroprivacy issues, but it also may soon pose evidentiary issues for gatekeepers who must determine the admissibility of fMRI lie detector testimony or results into evidence.[45]

Although different parties see fMRI applications through different lenses, colored by their desire to tap the potential inherent in fMRI detection capabilities, sooner or later someone from one of these interest groups will attempt to admit fMRI lie detection testimony or its results into evidence during a civil or criminal trial. One attempt has already occurred in the state of Illinois, when the State attempted to introduce expert testimony based upon fMRI brain function results to fend off a First Amendment challenge to its ordinance against violent video games.[46] Although the judge in that case

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40 *See* BRAINSTORM, *supra* note 35.

41 J. Peter Rosenfield, *Brain Fingerprinting: A Critical Analysis*, *available at* http://www.psych.northwestern.edu/nrosenfel/NewFiles/BFcritiquerevsub3-6.pdf (last visited Sept. 6, 2006).

42 The Committee on Science and Law, *Are Your Thoughts Your Own?: "Neuroprivacy" and the Legal Implications of Brain Imaging*, 60 CBA REC. 407, 416 (2005) (commenting on the potential use of brain fingerprinting to fight terrorism).

43 Jennifer Kulynych, *Psychiatric Neuroimaging Evidence: A High Tech Crystal Ball?*, 49 STAN. L. REV. 1249, 1254–57 (1997).

44 *See id*. at 1259–60.

45 Malcolm Ritter, *Brain Scans Can Find a Lie, Experts Say*, SAN DIEGO UNION-TRIB., Jan. 30, 2006, *available at* http://www.signonsandiego.com/uniontrib/20060130/news_130brain.html. *See also* Stacey A. Tovino, *Functional Neuroimaging Information: A Case for Neuro Exceptionalism?*, FLA. St. L. Rev. (forthcoming 2007).

46 *See* Entm't Software Ass'n v. Blagojevich, 404 F. Supp. 2d 1051 (N.D. Ill. 2005).

found the testimony lacked credibility, it may be only a matter of time before gatekeepers throughout America must begin holding hearings on the admissibility of fMRI lie detection studies in their courtrooms.

This article explores the potential evidentiary problems associated with fMRI lie detection testimony or its results that could soon be facing gatekeepers in the American courtroom. Part I of this article defines, or at least it will attempt to define, deception and the neuroanatomical regions of the brain that *may* be responsible for it. Once deception and its associated anatomy are covered, Part II of this article will hit the essential aspects of fMRI technology related to deception detection. Although many readers will balk at the mere thought of wading through such a section in a legal article, some understanding of this subject matter is essential to those wishing to understand why gatekeepers may or may not choose to admit fMRI deception detection evidence. Without such discussion, many attorneys may never fully grasp the essentials, which necessarily make or break their attempts to admit fMRI testimony or results. Part III of this article reviews the *Frye* and *Daubert* lines of treatment of novel scientific evidence in American courtrooms. Unfortunately, most of the existing case law addressing fMRI evidence is strikingly absent, and therefore, admissibility decisions derived from cases dealing with the modern polygraph machine and brain fingerprinting technology will serve as learning tools. Again, it is the science behind the technology that will play a critical role in court hearings focused on determining whether deception detection testimony or results will be admitted or excluded. Finally, Part IV of this article will analyze the current literature on fMRI lie detection and how the results from these studies may impact the future admissibility of fMRI lie detector results.

A. The Brain and its Executive Function Allow Humans to Deceive.

Obviously, people must learn how to control their behavior and monitor their thoughts so they can function in an orderly manner within their society.[47] Adequate control necessarily requires the orderly function of a set of "complex cognitions," which involve areas of the brain responsible for problem solving, modifications in behavioral responses to stimuli, planning, and behavioral inhibition

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[47] *See generally* Spence et al., *Neuroscience and the Will*, 15 CURRENT OPINION PSYCHIATRY 519 (2002).

and initiation.[48] The regions of the human brain responsible for such behaviors are collectively known as "executive function."[49] Not only does control require an intact executive function, but also it requires a working memory, which allows a normal person to manipulate useful data.[50] The precise loci of the cortical brain associated with these complex cognitions or executive function remains open to debate. Currently, most neuroscientists agree that regions of the prefrontal cortex are the portions of the brain most likely responsible for the executive function.[51] The prefrontal cortex is located in the anterior region of the frontal lobes of the cerebral hemispheres, which also lie in front of the premotor and motor strips.[52] The hallmark of this region is the presence of an internal granular layer IV, as opposed to the agranular premotor regions.[53] Executive function responses within this portion of the brain may be mediated through a series of adaptive networks or coordinated subprocesses.[54] This region may even have, as some suggest, a complex hierarchical neural structure, where the higher centers of the prefrontal cortex deal with novel or difficult events, and the lesser, "slave-like" brain systems focus on routine or repetitive tasks.[55] Diseases affecting these regions of the brain often illustrate their importance to control, when coordinated, controlled, and goal-oriented individuals suddenly exhibit disorganized behaviors.[56] Interestingly, these same loci may also allow individuals to successfully concoct deceptive stories to fool their intended victims. In fact, this complex process may involve more areas of the brain, such as orbitofrontal cortex, which some scientists believe is the region responsible for the pro-

[48] *See* Rebecca Elliott, *Executive Functions and Their Disorders*, 65 BRIT. MED. BULL. 49, 53–55 (2003).

[49] *Id.* at 50 (explaining that no intuitive lay concept of executive function exists, unlike those cognitive domains such as memory or attention, where executive function is defined by complex cognition).

[50] Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1756.

[51] *Id*.

[52] *Prefrontal Cortex*, WIKIPEDIA, http://www.en.wikipedia.org/wiki/Prefrontal_cortex (last visited Apr. 26, 2006) (explaining the anatomical relationships of the prefrontal regions of the cerebral hemispheres, which is a highly interconnected region of the brain, with connections to the Reticular Activating System and the limbic system that are involved with alertness, emotions, and control of pleasure, pain, anger, rage, panic, aggression, and basic sexual responses).

[53] *Id*.

[54] Elliot, *supra* note 48, at 50.

[55] Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1756.

[56] Elliot, *supra* note 48, at 50.

cess of deception.[57] Thus, the process of deception represents a "high stakes" task, which requires memory to recall the story, to manipulate the information, and control the human behavior.[58]

B. Memory Plays an Important Role in Deception.

Memory plays a crucial role in deception, because memory is the neural process that frequently involves the manipulation of knowledge retained and stored within the brain.[59] Many theories have been advanced to explain how the brain perceives and assimilates information into storage.[60] Different models have been proposed to explain the complex process of information storage known as memory. Some authors theorize that information must be rehearsed an adequate number of times before the desired bits of information become permanently stored.[61] Still others believe that information is stored into memory in a decision tree-like fashion, where pieces of information may become buried among other pieces of stored information, which then inhibits accurate retrieval at a later date.[62] To successfully fulfill the process of memory, the human brain must receive and perceive the desired information as important, which requires the brain to record, retain, and retrieve relevant information upon demand.[63] Each of these aspects of memory may be affected by internal or external stimuli, which may disrupt the process and cause errors in the memory process.[64] Not only can unwanted stimuli disrupt the process of laying down memory traces, but they may also affect recall by impeding the ability of a person to reconstruct or recognize important events.[65] If memory plays an integral part of deception, then information that is incorrectly stored due to a faulty memory could be as deceptive as the

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[57] Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1757.

[58] *Id*.

[59] *See* Annon, *supra* note 17, at 305.

[60] Elliot Salamon, *Mechanisms of Knowledge Learning and Acquisition*, 8 MED. SCI. MONITOR 133, 133 (2002).

[61] *Id*. at 135.

[62] *Id*. at 136.

[63] *See* Annon, *supra* note 17, at 305.

[64] *Id*. at 305 (explaining that recording phase may be affected by visual or sensory stimuli where the mind misrecords information, whereas retention, which involves both immediate, recent, and remote aspects of memory, may also be affected by the same stimuli leading to errors in memory).

[65] *Id*. at 319 (noting that distortion factors, such as mental disorders, internal states, time delays, and organic factors can all affect the various aspects of recall).

information intentionally meant to deceive its victim.[66] A working memory is critical to the process of deception, whether the deceptive act is one intentionally motivated by a person wishing to deceive another, or one unintentionally borne from a faulty recollection of the facts.

C. Distinguishing Intentional from Unintentional Distortions May Not Be So Easy.

Trustworthy information is the essence of what most people want when they search for the truth. Unfortunately, truth often lies somewhere between the event in interest, and the accurate recall of the event in question by the person responding to a request for relevant information.[67] People may, either intentionally or unintentionally, fail to provide truthful information. For example, if a person unintentionally fails to supply truthful information, then the person commits an omission. If, however, that person unintentionally provides faulty information thought to be true, then it qualifies as a confabulation.[68] These unintentional distortions of the truth may be caused by any of the factors that affect the processes of memory.[69]

Deception, on the other hand, is the deliberate or intentional concealment, distortion, fabrication, or manipulation of truthful information, whether successful or not, through the use of verbal or nonverbal cues that the communicator considers are false.[70] Deception or deliberate distortion may occur in the form of secrecy or confabulation.[71] Secrecy represents the deliberate omission of information, whereas a fabrication is the intentional provision of faulty information.[72] Some of these deliberately deceptive acts can be quite innocuous in their outcome, while others may qualify as criminal acts which yield unpleasant consequences for the unwary victim. For example, benign acts of deception that qualify as confabulation include the parents who tell their children about the Easter

[66] *Id.* at 305.

[67] *Id*.

[68] *Id.*

[69] *See* Annon, *supra* note 17, at 305–18.

[70] *See* Masip et al., *Defining Deception*, 20 ANALES DE PSIOLOGOGIA 147, 147 (2004) (providing the definition of deception where the three essential elements to any definition include: (1) the proposition of the sender is objectively false, (2) the belief by the sender that the proposition is false, and (3) the sender intends to deceive the receiver with his or her false message).

[71] *See* Annon, *supra* note 17, at 305.

[72] *See id*. at 318.

bunny or the boogeyman, or children who tell stories to their parents to avoid punishment.[73] Criminals, on the other hand, may employ more deceptive tactics, such as fraud, forgery, or perjury, to gain an advantage over their victims. These tactics may ultimately result in significant emotional, physical, or financial harms to the victim.[74] It is this latter group of activities that has driven societies to seek methods of deception detection, which will enable them to distinguish deliberate from nondeliberate distortions of the truth.

Data from a Department of Justice (DOJ) survey of criminal appeals filed in 1995 sheds light on why U.S. society may have an interest in technologies that are capable of detecting deception. Statistics published by the DOJ show that nearly sixty percent of the property-related offenses appealed between 1994 and 1995 were fraud-related, whilst less than five percent of public-order offenses were related to perjury.[75] These figures suggest that people attempt to utilize deception techniques to acquire property from their victims, while others see no problem with using them to deceive both judges and juries in order to escape the U.S. criminal justice system.[76] Unfortunately, the U.S. criminal justice system is also vulnerable to a more chilling kind of deception; since 1999 an estimated 355 innocent people have been wrongly convicted of crimes.[77] Between 1977 and 1999, 80 individuals of the roughly 6000 death-row inmates sentenced to death were later exonerated of their crime, which translates to approximately 1 in 75 gaining freedom on account of their innocence.[78] Because loss of freedom due to wrongful conviction exacts such a high price from the wrongly convicted, some commentators advocate the use of DNA evidence, polygraph,

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[73] *See id*.

[74] *See id*.

[75] U.S. DEP'T OF JUSTICE, BUREAU OF JUSTICE STATISTICS, COMPENDIUM OF FED. JUSTICE STATISTICS, 1995, 63 (1995), http://www.ojp.gov/bjs/pub/pdf/cfjs9505.pdf (reporting statistics from appeals filed by the type of criminal case and offense, where a total of 1767 property offenses were appealed, of which 1077 were related to fraud, while only 104 of 2197 public-order offenses were related to perjury and other offenses).

[76] *Id*.

[77] THE MIDWESTERN INNOCENCE PROJECT, http://www.innocenceprojectmidwest.org/brochure.pdf (explaining that there have been 159 post-conviction DNA exonerations since 1992, and a further 196 convicted defendants who have been exonerated between 1989 and 2003).

[78] Barry Scheck et al., *Convicting and Unconvicting the Innocent*, Dec. 27, 2000, http://www.law.uga.edu/academics/profiles/dwilkes_more/30convicting.html (reviewing statistics from the book ACTUAL INNOCENCE which portray a sobering view of the American justice system).

brain fingerprinting, fMRI, and other technologies to identify the truth to achieve a just result.[79]

Even the U.S. military worries about detecting deception in its personnel, and it too employs deception technology in its quest for the truth. For example, U.S. military authorities performed nearly 370,463 polygraph examinations between 1981 and 1996 to ferret out deceivers in its ranks.[80] Interestingly, the military administered less than one-fourth of their examinations during criminal investigations.[81] In 2003, the National Academy of Science reviewed the ability of the polygraph to screen for deception in individuals, and they concluded from their review of the existing literature that countermeasures employed by test subjects may degrade test accuracy.[82] The Review Committee also expressed its concern for the Department of Energy (DOE), which frequently uses this test to screen for deception within its employees. It warned the DOE that faulty polygraph results may cause it to falsely label loyal employees as security risks, whilst missing a significant number of individuals who could pose a significant threat to DOE security.[83] The Review Committee then urged the DOE and other federal agencies to explore alternative technologies as a means to supplement the use of the polygraph for deception detection.[84] Apparently, the federal government and others have heeded the advice of the Review Committee since the government and private industry are pursuing development of other technologies.[85]

Indeed, both the government and the private sector are actively investigating several technologies as potential deception detection devices. The one technology receiving the most attention from both groups is functional Magnetic Resonance Imaging

[79] Kulynych, *supra* note 43, at 1255–56.

[80] John A. Carr, Comment, *The Admissibility of Polygraph Evidence in Court-Martial Proceedings: Does the Constitution Mandate the Gatekeeper*, 43 A.F. L. REV. 1, 2 (1997).

[81] *See id* at 2.

[82] COMM. TO REVIEW THE SCIENTIFIC EVIDENCE ON THE POLYGRAPH, NAT'L RES. COUNCIL, THE POLYGRAPH AND LIE DETECTION, EXECUTIVE SUMMARY (2003), http://darwin.nap.edu/exexusumm_pdf/10420.pdf (noting that individuals, such as spies and terrorists, with a strong motivation to defeat the test could seriously undermine the value of polygraph-related screening procedures).

[83] *Id*. at 4–7 (indicating that the polygraph base detection rates are too low for its use as a detection device for potential violators of security at federal facilities, but they might serve a useful purpose by deterring or eliciting admissions and other similar purposes).

[84] COMM. TO REVIEW THE SCIENTIFIC EVIDENCE ON THE POLYGRAPH, *supra* note 82.

[85] Thompson, *supra* note 16, at 1608.

(fMRI).[86] Although several recent experimental trials with fMRI have demonstrated the capability of this technology to detect deception in volunteers, the overwhelming majority of these experiments have focused on detection of activity within a group of subjects rather than comparisons between individual subjects.[87] Most of these studies have focused on differences between groups, rather than the individual, because of limitations in the statistical software applications that are necessary to the analysis of fMRI data acquisitions.[88] Even so, many investigators tout fMRI lie detection technology over other technologies because this technology produces a diagnostic image, which possesses a very high spatial resolution, uses magnetism rather than ionizing radiation to generate its images, and provides both anatomical and functional images of the brain almost simultaneously.[89] These highly desirable imaging characteristics, however, would not have been possible without scientists understanding the physical principles that underlie nuclear magnetic resonance of the atom and those related to paramagnetic substances.

II. THE PRINCIPLES OF MRI HELP EXPLAIN THE BLOOD-OXYGEN-LEVEL-DEPENDENT (BOLD) EFFECT.

Unfortunately, a brief trip through the highly technical world of MRI physics is painfully necessary to help trial lawyers answer the technical questions related to fMRI technology that may arise during admissibility challenges. Obviously, most gatekeepers will want to know how the fMRI lie detector detects the blood-oxygen-level-dependent or BOLD effect, as an indirect measure of brain function during deception.[90] Fortunately, this trip will be kept as

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[86] *Id*. at 1602.

[87] *See* Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1761 (questioning the statistical power of currently published fMRI lie detector studies, where the studies reviewed, including those up to 2004, used averaged activities of subjects, and the authors were unaware of "any study to date that has provided convincing evidence of a physiology of deception at the level of the single subject").

[88] *See* C. Davatzikos et al., *Classifying Spatial Patterns of Brain Activity with Machine Learning Methods: Application to Lie Detection*, 28 NEUROIMAGE 663, 665 (2005) (explaining that the sparse number of studies correlating fMRI results within the individual, as compared to the existing studies that focus on group differences, may change over time as newer statistical analysis programs become available).

[89] Seong-Gi Kim & Kamil Ugurbil, *Functional Magnetic Resonance Imaging of the Human Brain*, 74 J. NEUROSCI. METHODS 229, 230 (1997).

[90] SCOTT A. HUETTAL ET AL., FUNCTIONAL MAGNETIC RESONANCE IMAGING, 159–84 (Sinauer Assoc., Inc. 2004).

short as possible, probably too short for most MRI experts, but it will be sufficient for the majority of trial lawyers who have little or no training in physics or MRI experience.

A. Lawyers Must Understand the Physical Principles Underlying Signal Acquisition to Explain Why fMRI Images Are Possible.

The atom is the fundamental building block of matter, and each atom is composed of a centrally positioned nucleus surrounded by a peripherally oriented electron shell filled with multiple orbiting electrons.[91] The nucleus of the atom contains positively charged protons as well as neutrons, which are electrically neutral and without any charge. The negatively charged electrons occupy the orbital shells of the atom while they spin around its nucleus.[92] The positively charged protons, conversely, spin like a top within the nucleus and generate an electric current as they spin. Their electrical current will induce a torque or magnetic moment if a strong magnetic field is applied to them.[93] If these spinning protons also possess an odd atomic number, they will possess both an angular momentum and a magnetic moment. These two physical properties greatly interest most magnetic resonance (MR) physicists, causing them to focus their initial research on the magnetic properties of atoms, such as ^{13}C, ^{19}F, ^{23}Na, and ^{31}P atoms.[94] Currently, most physicists study the hydrogen atom, which just so happens to be the most abundant one in the body.

Normally, the body is composed of many hydrogen protons, which are spinning in multiple different directions. If these spinning protons possess both a magnetic moment and an angular momentum, they will have magnetic resonance.[95] Because protons spin in many different directions, the sum of all the magnet moments yields a net magnetization that approaches zero, and thus, is almost im-

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[91] *Id*. at 49–97 (discussing the physics of MR signal generation beginning with the basic structure of the atom).

[92] *Id*.

[93] *Id.*

[94] *Id.* at 50.

[95] HUETTAL ET AL., *supra* note 90, at 49–50 (explaining that magnetic moments and angular momentum are created by the spinning of an atom within a magnetic field, where the field generates the magnetic moment and the mass of the atom produces the angular momentum; the field must contain both characteristics to magnetically resonate whereas in their absence, as in the presence of an evenly numbered atomic mass, the field will not resonate or generate a signal).

measurable.[96] To detect and measure this almost undetectable level of net magnetization, a strong magnetic field must be applied to these spinning protons to increase their net magnetization. Because the net magnetization may be very small in fMRI studies, the fMRI field strengths must be correspondingly strong, reaching magnet strengths that range from 1.5 to 4 Tesla or higher.[97] Photographers apply this same principle when they employ additional lighting to improve the ability of their film to acquire an image in dim lighting. Thus, magnets with higher field strengths boost the very weak signals emitted from the protons, and effectively enhance signal detection.

The strength of the magnetic field also causes the protons to spin like tiny gyroscopes with a motion known as precession. Precession means that the axis of the spinning proton is tilted away from the vertical axis.[98] Not only do these protons precess, but they also orient themselves along the vertical axis of the magnetic field based on their angular momentum. The directional orientation that a proton assumes depends on its energy state. High energy protons occupy an antiparallel position, compared to low energy protons, which orient themselves parallel along the axis.[99] The low energy orientation is the one atoms favor, and it is also the one most atoms will eventually achieve. More importantly, the higher the magnetic field strength a magnet is able to generate, the greater number of protons that will assume an antiparallel orientation.[100] Thus, the net magnetization for a particular volume of tissue is proportional to the difference between the spins in the parallel orientation versus those in the antiparallel direction.[101] It is this net magnetization that serves as the basis for MR signal generation.

Net magnetization, however, cannot be directly measured at the equilibrium state of the protons within a biological system, because it, again, has such a tiny value. Thus, any given proton must be disturbed through the addition of energy, which must be ab-

[96] *Id*. at 50.

[97] *Id*. at 53.

[98] *Id.* at 51.

[99] HUETTAL ET AL., *supra* note 90, at 52.

[100] *Id.* at 53 (explaining that the number of parallel spinning protons increases as the surrounding magnetic field strength increases, and by placing protons within a strong magnetic field one can increase the net magnetization of the same protons).

[101] *Id*. (noting that net magnetization can be defined in terms of vectors that possess either a longitudinal or transverse component, where the longitudinal component represents the parallel or antiparallel orientation, and the transverse orientation lies perpendicular to the magnetic field).

sorbed in order for the proton to generate an MR signal.[102] Movement of a proton from its high energy state to one of low energy state requires the emission of energy in the form of a particle called a photon.[103] Conversely, movement of a proton from a state of low energy to a higher one requires the absorption of energy in the form of a photon.[104] To create this excitation effect during MR imaging, a radiofrequency (rf) signal, which is a magnetic field that oscillates at the resonance frequency of a hydrogen proton, must be beamed into the volume of tissue.[105] Once a proton becomes excited, it begins to seek a lower energy state or relaxation by emitting electromagnetic energy, which is detected by the external detector coil.[106] Thus, the initial rf signal tips the net magnetization vector of all protons from a longitudinal orientation into the transverse plane, which represents the higher energy state. Over time, the net magnetization vector changes as it relaxes, which generates electromagnetic energy known as MR signal.[107] This MR signal is then received and processed through a series of mathematical computations and computer processing to arrive at the final MR image.[108]

Although the production of the final MR image requires the application of extremely complex mathematical processes, the key to the final product is the image contrast. Static contrast is affected by the type, number, and relaxation properties of the nuclei within

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[102] *Id*. at 54–55.

[103] *Id*. at 53–54.

[104] HUETTAL ET AL., *supra* note 90, at 54.

[105] *Id.* at 59 (explaining that nuclear spins may be characterized by both their magnetic moments and angular momentum expressed as vectors oriented in the same parallel direction, where the magnetic moment exceeds the angular momentum by a factor known as the gyromagnetic ratio; the more natural, low energy, parallel orientation of the protons can be altered to a high energy state by sending a radiofrequency pulse into the system, which causes the proton-spin to absorb electromagnetic energy that subsequently moves toward equilibrium at a low energy state by emitting electromagnetic energy; thus the frequency of either the absorbed or emitted electromagnetic energy depends only on the gyromagnetic ratio of the spin and the strength of the magnet field. Thus, the frequency or Larmor frequency of electromagnetic radiation that is needed to make spins move from one state to another can be calculated from gyromagnetic ratio and the strength of the magnetic field for a given MR scanner and atomic nucleus).

[106] *Id.* at 54.

[107] *Id.* at 73.

[108] *Id.* at 30–37 (explaining that MR scanners are composed of superconducting magnets that generate a static magnetic field, but require a radiofrequency coil to emit and receive radiofrequency signals as well as various types of coils to generate special information known as MR signals; both computer software and hardware are required to generate the exquisite anatomical as well as functional MR images).

the voxel (volume element) of tissue.[109] It highlights the basic anatomy of the human body. Motion contrast, on the other hand, detects movement and function of atomic nuclei.[110] Contrast may also be determined by the intrinsic properties of the tissues being imaged, where the endogenous contrast of tissue depends on intrinsic substances within the body, and the exogenous contrast requires the administration of a substance into the body.[111] The blood-oxygen-level-dependent (BOLD) effect that is utilized by fMRI is one form of endogenous contrast. Its effect depends on the amount of deoxyhemoglobin produced during brain metabolism.[112] Thus, the contrast determines the image information presented for interpretation.

Ultimately, acquisition of a given MRI image is governed by two important MR parameters known as the repetition time (TR) and the echo time (TE).[113] The acquisition times of these parameters affect the various aspects of contrast responsible for emphasizing the anatomical differences in human tissues, such as the gray and white matter of the human brain.[114] More importantly, these parameters are also responsible for the exquisite anatomical detail required for diagnostic imaging.[115] To emphasize the anatomy of brain tissue, an intermediately timed TR and relatively short TE interval are chosen to optimize T_1 weighting.[116] Conversely, a relatively prolonged TR interval and an intermediate TE interval produce T_2 weighted images, which bring out the fluid characteristics of human

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[109] HUETTAL ET AL., *supra* note 90, at 185 (defining a voxel (volume-element) as a three-dimensional element defined by three basic imaging parameters in cross sectional, computer generated images: field of view, matrix size, and slice thickness. Field of view represents the size of the imaging volume within an image section of tissue, usually given in centimeters. The size of matrix determines the number of voxels, and the image section or slice thickness may be in millimeters and usually defines the in-plane resolution).

[110] *Id.* at 99 (noting that static contrast parameters include density (proton density), relaxation times (T_1, T_2, and T_2*), molecular content, and general chemical content whereas motion contrast is sensitive to movement of atomic nuclei and of interest for its dynamic characteristics of the pools of protons within the brain, especially where it can be used to image blood flow or fluid movement through diffusion-weighted or perfusion-weighted imaging techniques).

[111] *Id.* at 99.

[112] *Id*.

[113] *Id*. at 100–01 (explaining that the repetition time is the time interval between excitation pulses, and the echo time or the time taken from excitation pulse to data acquisition is data acquired from *k* space, which is measured in milliseconds).

[114] *Id.* at 104.

[115] HUETTAL ET AL., *supra* note 90, at 104.

[116] *Id.* at 104–05.

tissues.[117] Both of these sequences are important to the acquisition of images in an fMRI experiment, but it is the T_2* contrast that is most sensitive to the amount of deoxygenated hemoglobin present during brain metabolism.[118] This contrast is achieved with long TR and medium TE sequences, but the pulse must be generated by a magnetic field gradient, not a refocusing pulse which eliminates the T_2* contrast effect.[119] Thus, one of the most common imaging techniques employed during fMRI experiments is gradient-echo imaging in which both echo-planar and spiral imaging are utilized, which results in the high-temporal resolution studies sensitive to functional changes.[120]

Echo-planar imaging, however, has its costs. These costs must be understood in order to understand the potential pitfalls associated with fMRI imaging studies, and in particular, fMRI lie detection. Echo-planar imaging relies on rapid gradient switching techniques, which means that the *k* space[121] will be filled by a single excitation pulse prior to significant decaying of T_2* or T_2.[122] The tradeoffs associated with this imaging technique are time, where image times must be prolonged, and magnetic gradients, which must be strong.[123] Because this technique also requires alternating lines scanned in opposite directions, the image data must be processed using Fourier transformation techniques to remove the resulting zigzag trajectory before images are reconstructed.[124] If this is not done, then serious artifacts occur.[125] Moreover, geometric distortions may arise from long readout times, which lead to reductions in both sampling frequency and readout gradient strengths.[126] Thus, the ac-

[117] *Id.* at 106–07.

[118] *Id*. at 109 (explaining that T_2* reflects the decay of the transverse magnetization, which is affected by spin-spin interaction (T_2) and alterations in the spin precession frequency that result from inhomogeneities in the magnetic field).

[119] HUETTAL ET AL., *supra* note 90, at 109–10.

[120] *Id*. at 126.

[121] *Id.* at 83 (explaining that *k* space is a term of convention created by MR researchers to help explain the relationship between MR signal, MR signal at a given point in time S(t), and the object to be imaged, M(x,y); thus, MR researchers create a mathematical and conceptual advantage to describe MR signal in image form).

[122] *Id*. at 120.

[123] *Id*. at 120–21.

[124] HUETTAL ET AL., *supra* note 90, at 121.

[125] *Id*.

[126] Seiji Ogawa et al., *Intrinsic Signal Changes Accompanying Sensory Stimulation: Functional Brain Mapping with Magnetic Resonance Imaging*, 89 PROC. NAT'L ACAD. SCI. U.S.A. 5951, 5954–55 (1992).

quisition of fMRI images is a highly technical process that is always subject to artifacts.

B. The Physiochemical Properties of Deoxyhemoglobin Help Create the BOLD Effect.

Although the previously discussed technical advances have provided the means to do functional imaging, it is the recognition of the magnetic properties of blood that makes it all possible. Amazingly, blood has magnetic properties that vary, depending on its state of oxygenation.[127] Because deoxyhemoglobin or deoxygenated blood has paramagnetic effects, it also has magnetic susceptibility which affects T_2* decay when a magnetic field is applied. Thus, the more blood that resides in its oxygenated state, the more MR signal it will emit and vice versa.[128] These alterations in the paramagnetic state of hemoglobin have been characterized as the BOLD Effect.[129] Physiologically, the oxygenated state of flowing blood in a tissue, such as brain, will necessarily depend on the metabolic activity of the neurons within brain tissue.[130] Metabolically active neurons utilize oxygen, which must be replenished through the delivery of more oxygen in the form of oxyhemoglobin, which will, in turn, require the removal of carbon dioxide produced during neuronal metabolism as deoxyhemoglobin.[131] These metabolic events characterize the hemodynamic response, which fMRI experiments detect as a change in MR signal from a low dark signal to one that has a high bright signal intensity on T_2* weighted images.[132] Thus,

[127] L. Pauling & C.D. Coryell, *The Magnetic Properties and Structure of Hemoglobin, Oxyhemoglobin, and Carbonmonoxy-Hemoglobin*, 22 PROC. NAT'L ACAD. SCI. U.S.A. 210 (1936) (describing the magnetic properties of hemoglobin, where oxygenated or oxyhemoglobin is diamagnetic (possessing no unpaired electrons resulting in zero charge) as opposed to deoxyhemoglobin which is paramagnetic based on its two unpaired electrons; therefore, the latter has magnetic susceptibility).

[128] K.R. Thulborn et al., *Oxygenation Dependence of the Transverse Relaxation Time of Water Protons in Whole Blood at High Field*, 714 BIOCHEMISTRY BIOPHYSIOLOGY ACTA 265 (1982).

[129] Seiji Ogawa et al., *Brain Magnetic Resonance Imaging with Contrast Dependent on Blood Oxygenation*, 87 PROC. NAT'L ACAD. SCI. U.S.A. 9868 (1990) (characterizing the in vivo effects of oxygenation and deoxygenation on T_2*, where they discovered dark bands of diminished signal in rat brains which led to the result that deoxygenated blood decreases T_2* and the measured MR signal relative to the presence of oxygen).

[130] Kim & Ugurbil, *supra* note 89, at 230.

[131] *Id*.

[132] HUETTAL ET AL., *supra* note 90, at 170 (explaining that the hemodynamic response (HDR) is a multiphasic response, where there is an initial delay of approximately two seconds or latent period followed by an inflow of oxygenated blood in response to the increasing metabolic demands of active neurons, which increases to the point where it exceeds the

the fMRI signal imaged during deception detection experiments does not directly measure neuronal activity; instead, it measures the metabolic activity of neurons responding to stimuli along with artifacts.[133]

C. MRI Artifacts Must Be Considered in the Acquisition and Final Interpretation of Any Brain Function Image.

All fMRI signal data must be processed in order to remove any artifacts it contains. Head motion is the most common and probably the most troubling artifact in any MR study, including fMRI. Both structural and functional MR images are exquisitely sensitive to motion, which means motion can destroy the data acquisition in any study.[134] To avoid this artifact in fMRI studies, the head must be immobilized physically with a physical restraint, such as a mask or bite block. Sometimes, it may even be necessary to immobilize subjects with sedation.[135] If restraint fails and the patient moves, then the image data may need manipulation after acquisition, or post-processing to salvage it.[136] Unfortunately, this image manipulation process is not always perfect, because it may also contain distortions due to magnetic field inhomogeneities or nonlinearity in the magnetic gradient field profile, which may not be correctable by rigid motion correction algorithms.[137] The inhomogeneities within static magnetic fields or rf coils that result in spatial errors usually require

amount of deoxygenated blood, as signal goes from dark to bright, reaching its maximum intensity at nearly five seconds, and then plateaus as neuronal activity persists, whereupon neuronal activity may cease, which results in a drop in amplitude of the signal or undershoot, where blood flow is reduced more quickly than blood volume which means signal is reduced below baseline that slowly returns to normal).

133 Kim & Ugurbil, *supra* note 89, at 235.

134 Fiachen Zhuo & Rao P. Gullipalli, AAPM/RSNA Physics Tutorial for Residents, *MR Artifacts, Safety, and Quality Control*, 26 RADIOGRAPHICS 275, 280–82 (2006) (noting that MR image data is obtained from absolute spatial locations, not relative relationships, so even slight movements in the position of the subject during scanning will create distortions, where there are large intensity transitions, such as those at the edges or interfaces of structures that include cortex and CSF fluid, bone and cortex, and bone and CSF fluid which can lead to misregistration of signal producing ring artifacts).

135 Kim & Ugurbil, *supra* note 89, at 235.

136 HUETTAL ET AL., *supra* note 90, at 260–80 (discussing the process of co-registration where the image data from misaligned images must be realigned or co-registered with a known target volume using a technique known as rigid-body transformation where it is assumed that the size and shape of two objects are identical and may be superimposed on one another through a series of manipulations performed in the x, y, and z planes).

137 Kim & Ugurbil, *supra* note 89, at 235.

additional correction techniques, such as mapping.[138] Likewise, images may undergo multiple different filtering techniques to improve image quality, but these techniques may also reduce the quality of data if they are applied improperly.[139] Not only is the quality of image data affected by artifacts, but it may also be affected by noise arising from the thermal effects of molecular motion system events such as scanner drift, or physiologic effects due to pulsation of blood or contracting muscles.[140]

Functional data acquired during fMRI studies is frequently low in resolution with little anatomical contrast, and may have distortions in its geometry and intensity.[141] To counterbalance these problems, functional data must be superimposed onto a high resolution image of the individual subject through coregistration algorithms.[142] Even if the functional data is well-localized within a given individual brain, the heterogeneity in brains across a set of subjects requires that each brain be normalized to uniform size and shape to allow for inter-subject comparisons of activity data.[143] Once brains are normalized, investigators may combine the data sets across individuals.[144] Additional attempts may be made to improve images through the employment of signal averaging techniques, which assume that the signal of interest remains identical across studies, and allows signal data to be averaged for a given individual or group of individuals.[145] Many of the recently reported studies rely on statistical parametric mapping (SPM) techniques, which are based on a voxel-by-voxel analysis of MR data.[146] This technique is useful for the assessment of regions of activation in some cognitive paradigms,

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138 Zhuo & Gullipalli, *supra* note 134, at 283–85.

139 HUETTAL ET AL., *supra* note 90, at 208.

140 *Id.*

141 *Id*. at 269.

142 *Id.*

143 *Id.* (explaining that the process of normalization transforms the MR data from an individual into one that will match the spacial properties of a standardized image of a brain, which may be derived from a sample of many brains from a given population).

144 *Id*.

145 HUETTAL ET AL., *supra* note 90, at 242 (identifying the technique of signal averaging as technique to improve the signal-to-noise ratio (signal is meaningful, and consistent from stimulus to stimulus and noise is random, unwanted information) within a given individual or a group of individuals where data sets are combined from multiple, similar stimulus events, usually tasks or stimuli in an experiment).

146 *See* Davatzikos et al., *supra* note 88, at 65 (discussing the utilization of the spatial parametric mapping technique in the analysis of MR data acquired in deception experiments, which is helpful in identifying regions of activation through a voxel-by-voxel analysis of active brain regions).

but it may be of limited value in detecting more complex spatially distributed patterns that are associated with lying.[147] Although most fMRI lie detection experiments allow for inferences to be made about the population of subjects,[148] as a whole, reliance on these averages of brain activity, instead of evaluations of the individual subject, may be problematic.[149] Even though quality research has been done with fMRI to date, it still is just a machine, which has its limitations, as all other machines before it. These limitations will likely impact the admissibility of fMRI lie detection data into evidence.

III. THE ADMISSIBILITY OF NOVEL SCIENTIFIC EVIDENCE REMAINS AN ISSUE FOR TRIAL JUDGES WELL BEYOND THE *FRYE* DECISION.

Almost all judges make rulings on the admissibility of new or novel scientific techniques or technologies at some point during their judicial careers in fulfilling their roles as gatekeepers.[150] Prior to the 20th century, most gatekeepers reviewed the qualifications of a potential expert witness only to ensure that the witness was qualified.[151] Scientific expertise was not even an issue for most gatekeepers until the beginning of the 20th century when science and technology blossomed and parties began bringing experts to the courtroom.[152] In fact, some legal scholars now claim that novel scientific evidence has overrun the courtroom, and that too much of it

[147] *See id*. at 65–66 (explaining that multi-variate nonlinear high-dimensional pattern classification techniques may be applied to fMRI data to overcome the current limitations inherent in SPM techniques by producing a higher classification accuracy for a given subject, which has not been reported in existing studies, which have also lacked subject specificity, making reliance on these results for the clinical application of fMRI to lie detection suspect).

[148] HUETTAL ET AL., *supra* note 90, at 242.

[149] *See* Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1761 (critiquing articles discussing experiments utilizing fMRI to detect deception published prior to 2004, where the authors could find "no study to date that has provided convincing evidence of a physiology of deception at the level of a single subject. Hence, there may well be a range of individual differences and it would be premature to extrapolate from the sorts of data we have considered to the individual suspect in the courtroom or the cell.").

[150] Lloyd Dixon & Brian Gill, *Changes in the Standard for Admitting Expert Evidence* (RAND Institute for Civil Justice 2002), *available at* http://www.rand.org/pubs/research_briefs/RB9037/index1.html.

[151] DAVID L. FAIGMAN ET AL., SCIENCE IN THE LAW 3 (West Group 2002).

[152] *Id.* at 2.

is nothing more than "junk science".[153] To make sense of all this novel science and technology, gatekeepers rely on the rules of civil procedure and evidence to help them separate the good science from the inadmissible junk.[154]

In 1923, the United States Court of Appeals for the District of Columbia may have been the first court to erect a gate to check the entry of novel scientific evidence into the courtroom when it enunciated its admissibility standard for novel scientific evidence in *Frye v. United States*.[155] The court in that case evaluated the admissibility of the results obtained from the famous "systolic blood pressure deception test" to support the claim of innocence made by a criminal defendant.[156] The opinion of an expert or skilled witness may be needed when the subject requires specialized knowledge or experience which is out of the range of the abilities of the jury.[157] The court held that novel scientific evidence must be sufficiently established to have gained general acceptance within the relevant scientific community.[158] Thus, the *Frye* test for admissibility requires the gatekeeper to identify the relevant scientific community to which the novel scientific technique or technology belongs, and then the gatekeeper must subsequently determine if the relevant group generally accepts it.[159] Some *Frye* courts further parse the general acceptance test into a three-staged approach.[160] Under this scheme, the gatekeeper determines in Stage I whether the doctrine or theory has general acceptance, followed by an analysis in Stage II of the general acceptance of the technique or technology, and in Stage III decides how well the expert applied the technique or technology to the particular event or case at trial.[161] Ultimately, the *Frye* test became the admissibility standard adopted by most state and federal courts un-

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153 Dixon & Gill, *supra* note 150.

154 Andrew R. Stolfi, Note, *Why Illinois Should Abandon Frye's General Acceptance Standard for the Admission of Novel Scientific Evidence*, 78 CHI.-KENT L. REV. 861, 866–67 (2003).

155 *See* Frye v. United States, 293 F. 1013 (D.C. Cir. 1923).

156 *See id.*

157 *See id.*

158 *See id.* at 1014 (declaring that the standard of review for the admissibility of scientific evidence is one where the science in question must be sufficiently established within the relevant scientific field to have gained general acceptance).

159 Stolfi, *supra* note 154, at 865.

160 Thomas L. Bohan, *Scientific Evidence and Forensic Science Since Daubert: Maine Decides to Sit Out the Dance*, 56 ME. L. REV. 101, 109 (2004) (explaining that some courts divide or treat the analysis of the general acceptance of the novel scientific technique or technology by the relevant community into *Frye* I, *Frye* II, and *Frye* III levels).

161 *Id.* at 109–10.

til the Supreme Court replaced it in 1993 with *Daubert* and its progeny. Nevertheless, some states continue to apply the *Frye* test to determine the admissibility of novel scientific evidence.[162]

During the time when *Frye* was in full force in both state and federal jurisdictions, gatekeepers favored the general acceptance test because it tended to support a cadre of experts who possessed the requisite expertise to testify on novel scientific techniques or technology.[163] By ensuring the ready availability of knowledgeable experts to these courts, the *Frye* decision promoted judicial efficiency by reducing the time parties spent haggling over the validity of novel scientific techniques, and fostered more uniform decision making.[164] Some critics objected to the *Frye* test because they considered it to be too stringent. They claimed that the test was prone to barring admissible evidence or testimony simply because too few experts may be available to support a general acceptance within the relevant, but relatively new scientific discipline.[165] Although *Frye* was the accepted admissibility standard for nearly a century in both state and federal courts, the Supreme Court chose a different path in 1993.

In 1993, the Supreme Court decided in *Daubert v. Merrell Dow Pharmaceuticals, Inc.* to adopt the Federal Rules of Evidence.[166] Thus, the Court chose the admissibility standard for novel scientific evidence currently contained within Rule 702[167] as the one all federal trial court judges were to use when they reviewed scientific evidence for admissibility.[168] In effect, the Court made the trial judge a "gatekeeper," whose responsibility is to review novel scientific evidence for admissibility.[169] The Court also mandated that any inquiry into the admissibility of scientific evidence should be a "flexible one," focusing on reliability and relevance of the principles underly-

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162 Stolfi, *supra* note 154, at 865.

163 Penelope Harley, *Minnesota Decides: Goeb v. Tharalson and the Admissibility of Novel Scientific Evidence*, 24 HAMLINE L. REV. 460, 475 (2001).

164 *Id.* at 475.

165 *Id*. at 477.

166 Daubert v. Merell Dow Pharm., Inc., 509 U.S. 579 (1993).

167 FED. R. EVID. 702 ("If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.").

168 *See id.*

169 *See id.*

ing the science under consideration.[170] The Court further directed its newly created gatekeepers to begin their inquiry into the admissibility of scientific evidence with Rule 104(a),[171] where gatekeepers would determine if a given expert had the requisite scientific knowledge to assist the trier of fact in understanding the relevant scientific facts.[172] This preliminary inquiry should then focus on scientific validity, and whether the reasoning or methodology may be acceptably applied to the facts of a given case.[173] Although the Court gave little guidance to future gatekeepers on how they were to conduct this flexible inquiry, it did, however, provide a list of nonexhaustive factors to aid them in their evaluation.[174] Armed with their Rules, federal gatekeepers began evaluating the admissibility of evidence. However, states and their gatekeepers were not so quick to adopt *Daubert* and its progeny, because the Supreme Court based its decision on the Federal Rules of Evidence, not the Constitution.[175]

Over subsequent years, the Court has made refinements in the admissibility standards set forth in *Daubert*.[176] For example, the Court in *Joiner* set the appellate standard of review for admissibility rulings made by the trial court as abuse of discretion.[177] It also instructed the trial court that it did not have to admit the opinion of the expert solely on the basis of the "*ispse dixit*" of the expert.[178] More importantly, the Court departed from its opinion in *Daubert*, when it announced in *Joiner* that conclusions were not entirely dis-

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170 Jollie A. Moreno, *Beyond the Polemic Against Junk Science: Navigating the Oceans that Divide Science and Law with Breyer at the Helm*, 81 B.U. L. REV. 1033, 1044–45 (2001).

171 FED. R. EVID. 104(a) ("Questions of admissibility generally. Preliminary questions concerning the qualifications of a person to be a witness, the existence of a privilege, or the admissibility of evidence shall be determined by the court, subject to the provisions of subdivision (b). In making its determination it is not bound by the rules of evidence except those with respect to privileges. (b) . . . When the relevancy of evidence depends upon the fulfillment of a condition of fact, the court shall admit it upon, or subject to, the introduction of evidence sufficient to support a finding of the fulfillment of the condition. . . .").

172 *See Daubert*, 509 U.S. at 592–93.

173 *See id.* at 593–94.

174 *See id.* at 593–94 (citing the following nonexclusive set of factors to assist the trial judge in determining admissibility: (1) whether the theory or technique has or can be tested (falsifiability), (2) whether the theory or technique has been subjected to peer review and publication, (3) whether the scientific technique has a known or potentially known rate of error, and (4) whether the theory or technique is generally accepted, or whether it has only a minimum of support).

175 Alice B. Lustre, *Post-Daubert Standards for Admissibility of Scientific and Other Expert Evidence in State Courts*, 90 A.L.R. 5th 453 (2003).

176 Moreno, *supra* note 170, at 1049–50.

177 Gen. Elec. Co. v. Joiner, 522 U.S. 136, 141 (1997).

178 *Id.* at 146.

tinct from the methodology used to reach them.[179] Thus, the gatekeeper became responsible for assessing any "analytical gap" that might exist between the existing methodology and any conclusions that were derived.[180] The Court then expanded its decisions in *Daubert* and *Joiner* in its 1999 *Kuhmo Tire Co., Ltd. v. Carmichael* decision, when it classified "skill- or experienced-based testimony" as expert testimony subject to Rule 702.[181] Not only did the Court place all expert testimony under Rule 702 and its gatekeepers, but it also said that all experts should be able to demonstrate "in the courtroom the same level of intellectual rigor" as they did during their experimental studies.[182]

Daubert and its progeny effectively created a two-staged analysis for the admissibility of scientific evidence.[183] In the first stage of the analysis, gatekeepers must determine whether the testimony of the expert pertains to scientific knowledge which incorporates the reliability-validity aspects of the theory or methodology.[184] The second stage then requires an assessment of whether the evidence "fits" the facts of the particular case.[185] Thus, gatekeepers following the *Daubert* line of cases must assess both skill and experienced-based testimony through the same lens that they view scientific evidence for admissibility.[186]

Daubert and its progeny are the current standard for all federal courts and most state courts, but remember that the general acceptance test of *Frye* is still followed in at least a third of all state jurisdictions. It is within this backdrop of evidentiary standards that the admissibility of fMRI lie detector results will be evaluated. Any attorney wishing to proffer fMRI lie detector results as evidence in either a criminal or civil case will have to be aware of the evidentiary standard used in that particular jurisdiction. If the evidence is offered in federal court, then it will be evaluated under Rule 702 through the lens of *Daubert* and its progeny. Conversely, if the evidence is submitted in a state court, then it might be Rule 702 and

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[179] *See id.*

[180] *Id.*

[181] Kuhmo Tire Co., Ltd. v. Carmichael, 526 U.S. 137, 151 (1999).

[182] *Id.* at 152.

[183] Moreno, *supra* note 170, at 1053.

[184] *Id*.

[185] *Id*.

[186] *Id*. at 1054.

Daubert, or it could be *Frye* and the general acceptance test, or it may even be some combination of the two.[187]

Although the Supreme Court claimed that *Daubert* and its flexible admissibility standards should allow more novel scientific evidence to come in than under the general acceptance test of *Frye*, some commentators found that it actually had an opposite affect.[188] If in fact this is the case, then fMRI lie detector results may face a stiff challenge in court, regardless of the evidentiary standard under which they are reviewed. With this in mind, it may be helpful to consider how the federal and state courts have viewed similar types of lie detector evidence in the form of the polygraph and brain fingerprinting.

A. Will a Gatekeeper Admit or Not Admit Polygraph Testimony, That Is the Question.

As mentioned earlier in this discussion, the polygraph has a long and checkered history in the American legal system. Even so, its track record through the court system may provide insight into what lies ahead for attorneys, who attempt to admit fMRI lie detector results or testimony into evidence. The first known attempt to introduce polygraph-like testimony came in 1923, when a defense attorney proffered the results from the "the systolic blood pressure deception test" as evidence for innocence of an accused murderer in *Frye*.[189] Although this test was the forerunner of the modern polygraph, it relied only on elevations in systolic blood pressure, as a single physiological indicator of deception, elicited during questioning.[190] The modern polygraph, when compared to the systolic blood pressure test, is a much more sophisticated stress test, which has been improved over the years with the addition of cardiographs (measuring heart activity), pneumographs (measuring respiratory activity), and galvanic skin electrodes (measuring sweat gland activ-

[187] Lustre, *supra* note 175, at § 2 (noting that twenty-five states follow Rule 702 while another fifteen states continue to adhere to the general acceptance test of *Frye*, and a further six states use a combination of the two or their own test).

[188] Dixon & Gill, *supra* note 150 (noting that holding factors such as case type, area of the evidence, and federal appellate court constant exclusion of evidence jumped from 53 percent in the two years preceding *Daubert* to 70 percent during years 1996 and 1997, where challenges to expert evidence were more often fatal to the case than not).

[189] *See Frye*, 293 F. at 1013.

[190] Bohan, *supra* note 160, at 106.

ity).[191] The polygraph expert who testifies in the modern courtroom relies on readings from all of these sensors to detect stress responses as indicated by alterations in the autonomic nervous system activity.[192]

Currently, polygraph testing procedures use oral questions that are administered to the respondent, and the examination techniques come in three different forms.[193] Each of these examination techniques requires that the examiner interview the respondent before the test is administered, and then the examiner must follow completion of the test with a post-examination interview.[194] The test is scored and given a positive or negative numerical value.[195] Although the polygraph has been studied more than any other test, and utilized the most by both civilian and government organizations, it continues to be criticized in both the scientific and legal communities.

Many of the criticisms levied against this test have also influenced gatekeepers and their treatment of the admissibility of this evidence.[196] One of the chief problems with the polygraph is its failure to actually detect lying.[197] In 2003, the Research Council of the National Academies released its report on a study that it conducted on the polygraph.[198] The Research Council concluded that there

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[191] Yvette J. Bessent, *Evidence of Innocence Offered by the Criminal Defendant, Not So Fast: Admissibility of Polygraph Evidence and Repressed Memory Evidence When Offered by the Accused*, 55 U. MIAMI L. REV. 975, 978 (2001).

[192] David Gallai, *Polygraph Evidence in Federal Courts: Should It Be Admissible?*, 36 AM. CRIM. L. REV. 87, 91 (1999) (explaining that instruments, such as the cardiograph, pneumograph, cardio-cuffs, and sensor electrodes measure physiological changes in respiration, blood pressure, blood flow, pulse, and galvanic skin responses, which occur due to adversity and anxiety created during the telling of a falsehood).

[193] *See id.* at 91–92 (discussing the three current examination techniques that questioners may perform that include: (1) relevant-irrelevant technique (the oldest technique which compares the strength of a response to a relevant question (strongest) to an irrelevant one); (2) controlled question technique (the most common technique) which utilizes the strength of a response to a controlled question (irrelevant but provoking a physiologic response) to a relevant question (which provokes an even greater response); and (3) directed lie control technique which involves the use of a control question (subject directed to lie to it) that is compared to responses made to relevant questions).

[194] *See id*. at 91.

[195] *See id*. at 93.

[196] Bohan, *supra* note 160, at 118.

[197] *Id*. (reporting that the polygraph detects responses to stress, not lying or truth telling by the subject).

[198] NAT'L RESEARCH COUNCIL, NAT'L ACADEMIES, THE POLYGRAPH AND LIE DETECTION (2003), *available at* http://darwin.nap.edu/execsumm_pdf/10420.pdf (concluding that the polygraph was insufficient for security screening because firstly, its accuracy was lower than required to evaluate specific incidents, and secondly, it only targeted a small percentage of

were an insufficient number of good studies evaluating the accuracy of the polygraph, and that the test was highly dependent on the experience and training of the examiner administering the test.[199] The Committee also raised concerns regarding the accuracy of the test in situations where subjects may resort to countermeasures that could be used to fool both the examiner and the machine.[200] Countermeasures are tactics employed by respondents, who rely on activities, such as the self infliction of pain, to create a false physiological response to the control questions.[201] Therefore, gatekeepers in both state and federal jurisdictions have tended to treat admissibility issues differently. Because gatekeepers, in general, will likely not have prior experience with fMRI lie detector testimony or results, they may handle any admissibility issues coming before them in a similar fashion to those related to the polygraph.

B. The Admissibility of Polygraph Testimony or Results Follows an Absolutely No, Maybe Yes or No, or Maybe Yes Paradigm.

The admissibility of polygraph testimony or evidence into state and federal court varies, depending on the test of admissibility utilized within a given jurisdiction. Currently, American jurisdictions are divided where splits occur between the *Frye* and *Daubert* admissibility tests for the admissibility of scientific techniques or technology. Obviously, the first attempt to introduce polygraph-like evidence under the general acceptance test in *Frye* did not go well, and this pattern has continued in the jurisdictions that continue to follow *Frye*.[202] Currently, federal and state jurisdictions treat the admissibility of polygraph testimony, regardless of the admissibility standard invoked, in one of four ways: (1) per se bar (no), (2) admit it, if both parties stipulate to it (maybe yes or no), (3) admit it based upon a substantive right, if stipulated (maybe yes or no), and (4) admit at the discretion of the trial court (maybe yes).[203]

those who were actually guilty, and it also had a high number false positives, as those who were actually innocent).

[199] Bohan, *supra* note 160, at 123–24 (discussing the findings of the Research Council, which concluded that no validation studies of the polygraph test support utilization of this technology for screening purposes).

[200] *See* Gallai, *supra* note 192, at 95.

[201] *See id*.

[202] U.S. v. Scheffer, 523 U.S. 303, 312 n.7 (1997) (noting that federal and state courts were in agreement that polygraph evidence was inadmissible under the *Frye* test).

[203] *See* Carr, *supra* note 80, at 6–16.

At least four federal circuit courts, most state jurisdictions, and all military courts just say no by maintaining a per se bar on the admissibility of polygraph testimony or evidence.[204] These courts bar findings from polygraph examinations because its test results are considered unreliable, and any testimony that is given related to its results may invade the province of the jury by unduly influencing their determination of the guilt or innocence of a defendant.[205] In jurisdictions operating under the admit it if both parties stipulate to it scheme, trial courts will admit the evidence if it passes the admissibility test of the jurisdiction in question.[206] They admit through stipulation because the process of stipulation serves as a waiver of the per se bar against this evidence, and the parties have effectively received fair notice of the testing procedures and examiner involved in the administered test.[207] At least one federal court, the Seventh Circuit, may admit it as a substantive right, if parties stipulate to it.[208] Other jurisdictions, such as the Fifth, Seventh, and Ninth Circuits, say "yes" if the trial judge determines that this evidence should be admitted.[209] Again, it is at the discretion of the court, and it must pass through *Daubert* and Rule 702.[210]

If polygraph testimony is proffered by one party in a jurisdiction that does not have a per se bar against it, then it is likely going to face a challenge by the opposing party. If the jurisdiction follows *Daubert* and its progeny, or Rule 702, then the trial judge will evaluate the admissibility of the polygraph test methodology for both admissibility-reliability and relevance.[211] The court will likely evaluate the reliability of the technology by testing the methodology underlying polygraph testing against the four factors outlined by the Court in *Daubert* and now incorporated into Rule 702.[212] If the court

204 *See id*. at 7–8 (citing the Second, Fourth, Tenth, and D.C. Circuits as holding a per se bar on the admissibility of polygraph testimony or evidence because the exam is unreliable).

205 *See id*. at 8.

206 *See id*.

207 *See id*. at 9 (identifying the Sixth, Eighth, and Eleventh Circuits as permitting polygraph findings into evidence upon stipulation of both parties, if it passes under Rule 702, and at least seventeen state jurisdictions allow it, if the parties stipulate to it).

208 *See* Carr, *supra* note 80, at 14.

209 *Id*. at 14–15.

210 *See id*. at 15 (citing the above federal circuit courts as allowing the admission of polygraph findings into evidence at the discretion of the trial judge, whereas only one state jurisdiction follows this pattern).

211 Gallai, *supra* note 192, at 94.

212 *Id*. (discussing the application of *Daubert* and its progeny to polygraph technology and how a court might analyze it for admissibility).

considers the falsifiability or testability of the technology, then it will likely consider the results from the National Academies, which identified the absence of sufficient studies evaluating test validity. Testability and methodology issues also arise due to the inability of the test to directly measure deception, and its susceptibility to detection through the use of countermeasures.[213] More importantly, any court considering the admissibility of polygraph evidence or testimony is likely to question whether it can pass peer review based on the 2003 report delivered by the National Academies.[214] The low error rates quoted in some studies have been questioned, since some evaluators may have excluded indeterminate tests leading to under reporting of the true error rate.[215] Clearly, the polygraph is likely to have difficulty passing the general acceptance factor under *Daubert*, since scientific consensus on the reliability of the test is lacking.[216] More importantly, most courts do not consider the test reliable.[217]

C. The Court Supports Military Rule of Evidence 707, and Says No to the Polygraph.

The Supreme Court denied polygraph evidence or testimony in military cases in 1998. In *U.S. v. Scheffer* the Court upheld the bar against admitting polygraph evidence under Military Rule of Evidence 707.[218] The Court found that the refusal of the trial court to admit polygraph testimony did not violate the rights of the accused.[219] The airman defendant in *Scheffer* worked as a drug informant for the military, and was subject to random drug screens.[220] On one occasion, a drug screen tested positive for methamphetamine, and the airman was brought before a military court for court martial.[221] During the trial, his defense attorney attempted to admit a pre-drug screen polygraph test to support their claim that the positive drug result was related to an innocent ingestion of the offend-

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[213] *Id.* (discussing the problems related to admissibility where the polygraph detects changes in the autonomic nervous system due to anxiety, which are an indirect indicator of deception).

[214] COMM. TO REVIEW THE SCIENTIFIC EVIDENCE ON THE POLYGRAPH, *supra* note 82, at 3.

[215] *See* Gallai, *supra* note 192, at 99.

[216] *See Scheffer*, 523 U.S. at 310 (1998) (noting that a general consensus on the reliability of the test is lacking among scientists).

[217] *See* U.S. v. Canter, 338 F. Supp. 2d 460, 463 (S.D.N.Y. 2004).

[218] *See Scheffer*, 523 U.S. at 305.

[219] *See id.*

[220] *See id.*

[221] *See id.* at 306.

ing agent.[222] The results of the polygraph taken prior to the urine drug screening test showed no deception to three relevant questions related to drug screening asked by the polygraph examiner.[223] The military trial court would not admit this evidence based on Rule 707, which serves as a per se bar to the admissibility of polygraph evidence.[224] The defendant then appealed to the Air Force Court of Criminal Appeals, which affirmed the trial court's ruling.[225] On further appeal to the U.S. Court of Appeals for the Armed Forces the court reversed and held that exclusion of polygraph testimony under Rule 707 did violate the Sixth Amendment right of the accused to present a defense.[226]

The Supreme Court granted certiorari and reversed the Court of Appeals for the Armed Forces holding that Rule 707 serves several legitimate interests in criminal proceedings.[227] Rule 707 was neither arbitrary nor disproportionate in the process.[228] The Court reasoned that Rule 707 ensured that only relevant evidence would be admitted, preserved the role of the jury in determining the credibility of evidence, and avoided litigation of the collateral issue of test reliability.[229] Moreover, the Court held that the Rule did not violate the right of the defendant to present a defense, unlike the case in *Rock* v. *Arkansas*, where the hypnotically-refreshed testimony from the accused was allowed because it came from the mouth of the accused in her own defense.[230] The Court went on to distinguish the testimony of a polygraph expert from the testimony given by experts on DNA, ballistics, or fingerprint evidence. Testimony from a polygraph expert presents just another opinion to the jury, unlike an expert who testifies on DNA, ballistic, or fingerprint evidence which relate to factual matters outside the knowledge of the jurors.[231] More importantly, the Court noted that jurisdictions were justified in barring polygraph testimony, because such testimony

[222] *See id*.

[223] *See Scheffer*, 523 U.S. at 306.

[224] *Id.*

[225] *Id.* at 307.

[226] *Id.* at 303.

[227] *Id.* at 308–09.

[228] *Id.* at 308.

[229] *See Scheffer*, 523 U.S. at 309.

[230] Rock v. Arkansas, 483 U.S. 44, 47, 61–62 (1987).

[231] *Scheffer*, 523 U.S. at 313.

could give the impression of infallibility of polygraph evidence to a jury.[232]

Although the holdings of the Court in this case only apply to military jurisdictions, it suggests that the current majority of the Court may resist the admissibility of polygraph testimony or evidence. The dissent registered by Justice Stevens, on the other hand, argues that the decision reached by the majority did not comport with the flexible inquiry afforded by *Daubert*.[233] Justice Stevens also expressed the opinion that the blanket exclusion of evidence, such as testimony pertaining to the results from a polygraph test, may violate the Sixth Amendment right of the accused to mount a defense.[234] If this is the case, it may be argued that the gatekeepers, in both military and civilian courts, should allow the review of testimony delivered by polygraph experts in a fair and flexible fashion rather than resorting to a per se bar. However, some commentators believe that if a civilian case with facts similar to those in *Scheffer* makes its way before the current Court, the Court will likely reach the same result.[235] Even so, some jurisdictions continue to weigh the admissibility of this type of evidence with some admitting it while most continue to exclude it.[236] If this is the future for all polygraph testimony, then it is understandable why alternative methods of deception detection are being actively pursued by both the government and civilians alike.

D. Proponents of Brain Fingerprinting Say It Detects "Guilty" Knowledge.

Some have hailed brain fingerprinting technology as the next "truth meter" because this technology measures different physio-

[232] *See id.* at 313.

[233] *See id.* at 322.

[234] *See id.* at 331 ("[T]he Court is quite wrong in assuming that the impact of Rule 707 on respondent's defense was not significant because it did not preclude the introduction of any 'factual evidence' or prevent him from conveying 'his version of the facts to the court-martial members' . . . A rule that bars him 'from introducing expert opinion testimony to bolster his own credibility,' . . . unquestionably impairs any 'meaningful opportunity to present a complete defense'; indeed, it is sure to be outcome determinative in many cases.").

[235] Bessent, *supra* note 191, at 994.

[236] *Id*. at 1000 (expressing the view that courts admit polygraph test results depending on what they show and who wants to admit them, where test results supporting the defendant are barred, as opposed to those against the defendant are allowed, which may eventually change as the technology improves in reliability).

logic parameters than those detected during a polygraph test.[237] Brain fingerprinting relies on the detection of electrical impulses emitted from the brain, which can be registered and recorded by a machine known as an electroencephalograph.[238] The electroencephalograph records a P300 wave[239] and a memory-and-encoding-related-multifaceted-electroencephalographic (MERMER) response emitted from the brain responding to stimuli.[240] The waves are detected and recorded, and then analyzed by a sophisticated and proprietary algorithm computer program.[241] The P300 wave is an electrically positive wave that is emitted some 300 milliseconds after a person sees a stimulus of special significance.[242] Part of the MERMER contains a P300 wave, which follows by some 300 to 800 milliseconds.[243] The P300 wave or event-related potential (ERP) shows only a peak electrical response, whereas the MERMER exhibits a peak and a dip or valley response pattern.[244] The P300 wave or ERP tracings are recorded in subjects with relevant information stored in their memories.[245]

These responses are elicited by an examiner who tests the subject for relevant knowledge of the salient features or events associated with a crime. The examiner uses words, pictures, or sounds to evoke a response from the subject, who has relevant or "guilty"

[237] Tom Paulson, *Brain Fingerprinting Touted as Truth Meter*, SEATTLE POST-INTELLIGENCER, Mar. 1, 2004, *available at* http://seattlepi.newsource.com/local/162685_brain01.html (discussing the events surrounding the appeal of convicted murderer and death row inmate Jimmy Ray Slaughter, who relied on brain fingerprinting technology of Larry Farwell to show he lacked key knowledge of the events of the double murder that put him on death row).

[238] *See Brain Fingerprinting Testing Ruled Admissible in Court*, BRAIN FINGERPRINTING LABS., http://www.brainwavescience.com/Ruled%20Admissible.php [hereinafter *Brain Fingerprinting Testing*] (last visited Jan. 7, 2007).

[239] Lawrence A. Farwell & Emanuel Donchin, *Talking Off the Top of Your Head: A Mental Prosthesis Utilizing Event-Related Brain Potentials*, 70 ELECTROENCEPHALOGRAPHY & CLINICAL NEUROPHYSIOLOGY 510 (1988).

[240] *Summary Information*, BRAIN FINGERPRINTING LABS., http://www.brainscience.com/ExecutiveSummary.php [hereinafter *Summary Information*] (last visited Mar. 3, 2005) (explaining the science and techniques underlying the brain fingerprinting test conducted by Lawrence A. Farwell).

[241] *See id.* (discussing the analysis of the P300 wave as being part of a larger brain-wave response known as a MERMER (memory-and-encoding-related-multifaceted-encephalographic response) that was patented by Dr. Farwell and part of a sophisticated brain-wave analysis algorithm).

[242] *See id*.

[243] *See id*.

[244] *See id*.

[245] *See id*.

knowledge.[246] Subjects are presented with words and pictures, which represent "target," "irrelevant," and "probe" stimuli, to trigger responses.[247] Using this technique, Dr. Farwell claimed in one test that brain fingerprinting was able to distinguish FBI agents from civilians with one hundred percent accuracy.[248] Dr. Farwell currently claims in materials posted on his web site that many other tests showed an almost flawless performance of this technology.[249] According to the posts on the Brain Fingerprinting Laboratories home page, Dr. Farwell has utilized brain fingerprinting to help exonerate individuals.[250] Dr. Farwell even boasts that the test will survive a challenge under *Daubert*.[251] A closer examination of these cases reveals that the gatekeepers and the appellate judges who have reviewed his work may have a slightly different take on the ability of this technology to pass the evidentiary scrutiny required for novel scientific evidence posed by *Daubert* and its progeny.

Perhaps the *Harrington* case held the most hope for brain fingerprinting technology passing an admissibility challenge posed by *Daubert* and its progeny.[252] In that case, Dr. Farwell testified on the behalf of Terry Harrington, a convicted murderer, during his post-conviction hearing in an Iowa district court. Dr. Farwell presented brain fingerprinting test results on Harrington that indicated Har-

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[246] *See Summary Information*, *supra* note 240.

[247] Andre A. Moenssens, *Brain Fingerprinting—Can It Be Used to Detect the Innocence of Persons Charged with a Crime?*, 70 UMKC L. REV. 891, 897 (2002) (explaining the testing procedure for questioning subjects related to a crime or other events based upon testimony delivered by Dr. Farwell).

[248] *See Brain Fingerprinting Testing*, *supra* note 238 (recounting the results of a study reported by Dr. Farwell conducted with FBI scientist Dr. Drew Richardson, where they used brain fingerprinting test to detect people within a group that were FBI agents from those that were not by asking questions only an FBI agent would have the information to respond to their questions, and Dr. Farwell further claims that the study demonstrated 100 percent accuracy in three studies conducted for the U.S. Intelligence and the Navy).

[249] *See Summary Information*, *supra* note 240; *Wave Science Laboratories*, BRAIN FINGERPRINTING LABS., http://www.brainwavescience.com/reference.htm (last visited Apr. 30, 2006).

[250] *See Brain Fingerprinting Testing*, *supra* note 238.

[251] Tom Paulson, *supra* note 237 (stating that a judge ruled that brain fingerprinting in the post-conviction appeal for a new trial of Terry J. Harrington met the four factors utilized in *Daubert* to access the reliability of the scientific evidence).

[252] Harrington v. State, 659 N.W.2d 509 (Iowa 2003) (overturning conviction by concluding that (1) there was a timely appeal; (2) the statute of limitations had not run on that action; and (3) defendant was entitled to relief because of a due process violation, relating to suppression of police reports which prosecutors knew or should have known, because the police but did not make them available to the defense and therefore, they were suppressed in terms of the *Brady* rule).

rington did not possess knowledge of the crime.[253] Although the district judge heard the testimony and admitted it, he denied Mr. Harrington his post-conviction relief based on other grounds. The judge actually believed that all of the claims raised by Mr. Harrington were time-barred.[254] Dr. Farwell, in the documents stored on his website, claimed that the judge recognized that the brain fingerprinting test met the criteria of *Daubert*, and the judge also ruled that the evidence was material.[255] Even so, the outcome of the case turned on issues unrelated to the results acquired from the brain fingerprinting test, and further appeals were made to the Iowa Supreme Court.[256]

Once the case reached the Iowa Supreme Court, it reached a slightly different conclusion than the one portrayed by Dr. Farwell. Mr. Harrington received his post-conviction relief, but it was supplied on due process grounds, not the testimony proffered by Dr. Farwell.[257] The court did not even address the admissibility of brain fingerprinting results under *Daubert* and its progeny.[258] Notwithstanding any claims made by Dr. Farwell to the contrary, brain fingerprint technology remains untested within the evidentiary crucible of *Daubert*.

The next case to invoke brain fingerprinting evidence came in 2004, when Jimmie Ray Slaughter attempted to proffer testimony from Dr. Farwell in support of his request for post-conviction relief.[259] Not only did Mr. Slaughter submit testimony from Dr. Farwell, but he also provided the court with his newly discovered DNA evidence from hair samples.[260] The Court of Criminal Appeals acknowledged that Dr. Farwell testified on March 2004, but the court also recognized that Dr. Farwell was supposed to produce a comprehensive report detailing the methodology of his test.[261] The court went on to say that nearly six months had passed since it

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[253] *See* Moenssens, *supra* note 247, at 906 (citing testimony delivered by Dr. Farwell at the post conviction hearing).

[254] *See Harrington*, 659 N.W.2d at 512.

[255] Paulson, *supra* note 237.

[256] *See Harrington*, 659 N.W.2d at 512.

[257] *See id.* at 522–24 (noting that defense counsel did not have the essential facts since multiple police reports were withheld, which resulted in a *Brady* violation).

[258] *See id*. at 516 (stating that the scientific testing evidence was unnecessary, and was going to be given no further consideration on appeal).

[259] Slaughter v. State, 105 P.3d 832 (Okla. Crim. App. 2005).

[260] *See id*. at 836.

[261] *See id.* at 834.

made its request for the report, which was never delivered.[262] Even though Dr. Farwell failed to respond, the court proceeded through the list of nonexclusive factors related to *Daubert*.[263] During the hearing, the court opined that the defendant failed to provide the following: evidence of extensive testing, extensive review of the methodology in peer review journals, demonstration of a very low error rate, objective standards of control of its operation, and general acceptance of the test within the scientific community.[264] In short, the court concluded that the failure of Dr. Farwell to produce his report indicated that no such report or evidence existed.[265] The defendant again requested a rehearing based on the brain fingerprinting testimony, which the court denied due to (1) the failure of Dr. Farwell to produce a report, (2) a lack of sufficient evidence, and (3) a belief that the test would not survive *Daubert*.[266] On March 15, 2005, Jimmie Ray Slaughter was executed by lethal injection.[267] Nevertheless, the website run by Dr. Farwell continues to post one article still hoping that Mr. Slaughter will make a successful appeal.[268]

Based on these two cases, it seems very unlikely that brain fingerprinting will pass through any judiciary unscathed by *Daubert* and its progeny. The existence of multiple publications in peer reviewed journals suggests that the technology has been extensively reviewed in the literature.[269] It also suggests that the methodology of brain fingerprinting has been tested, which is further supported by testing by the DOD and the FBI.[270] More importantly, Dr. Farwell claims ninety-nine percent statistical confidence in his results.[271] Notwithstanding these claims, the test does not enjoy general ac-

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[262] *See id.*

[263] *See id.*

[264] *See Slaughter*, 105 P.3d at 835.

[265] *See id*. at 835.

[266] Slaughter v. State, 108 P.3d 1052 (Okla. Crim App. 2005), *cert. denied*, 525 U.S. 886 (2005).

[267] *Episode 8: Brain Fingerprinting* (PBS television broadcast May 4, 2004), *available at* http://www.pbs.org/wnet/innovation/about_episode8.html (presenting transcripts for program covering the use of brain fingerprinting).

[268] *See Brain Fingerprinting Laboratories*, BRAINSCIENCE.COM, http://www.brainscience.com/Chemistry.php (last visited Mar. 23, 2006).

[269] *Publications*, BRAINSCIENCE.COM, http://www.brainscience.com/Publications.php (last visited Mar. 23, 2006).

[270] Paulson, *supra* note 237.

[271] *Id*.

ceptance within the relevant scientific community.[272] Even the Court of Criminal Appeals expressed reservations about the ability of this technology to pass the admissibility challenge posed by *Daubert*, when Dr. Farwell, after six months, failed to produce a report.[273]

Clearly, the court in *Slaughter* had its doubts about the reliability and validity of the methodology of brain fingerprinting to detect the presence or absence of relevant information related to a crime. Even though at least one district court formally heard brain fingerprinting testimony, it was not determinative in that case, or any of the appellate cases. Not only do the opinions rendered in these cases undermine assertions made by Dr. Farwell on his website regarding the importance of his technology to judicial outcomes, but they also cast doubts on the ability of this technology to be admitted into evidence in jurisdictions adhering to the *Daubert* line of cases. Moreover, they raise potential questions regarding the ability of the fMRI lie detector technology to pass either the general acceptance test of *Frye* or the reliability-validity test posed under *Daubert* and its progeny.

IV. GATEKEEPERS MAY SEE fMRI LIE DETECTOR ADMISSIBILITY ISSUES SOONER RATHER THAN LATER.

Since Spence and his colleagues published their first article on fMRI deception detection in 2001,[274] a further twelve articles discussing neural correlates of deception and fMRI have been placed into the scientific literature.[275] Not only has fMRI lie detection capa-

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272 Moenssens, *supra* note 247, at 917 (explaining that the brain fingerprinting test would not pass the general acceptance test because it does not appear to have general acceptance within the scientific community).

273 *Slaughter*, 105 P.3d at 835–36 (Denying post-conviction relief because it dispensed with the issue of brain fingerprint test in their second hearing, where they doubted whether it would survive a challenge under *Daubert*. Dr. Farwell never supplied the comprehensive report regarding the testing of the brain fingerprint technology, and they repeated their doubts about the ability of this technology to survive scrutiny under *Daubert*).

274 Sean A. Spence et al., *Behavioral and Functional Anatomical Correlates of Deception in Humans*, 12 NEUROREPORT 2849 (2001) [hereinafter Spence et al., *Behavioral*].

275 *See* PubMed Search, *available at* http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?CMD=Pager&DB=pubmed (searching with key words fMRI AND "functional magnetic resonance imaging, deception OR lie detection" will retrieve 103 citations of which 13 are specifically focused on the application of fMRI technology to lie or deception detection, and since Spence et al., *supra* note 274 include (1) Langleben et al., *Brain Activity During Simulated Deception: An Event-Related Functional Magnetic Resonance Study*, 15 NEUROIMAGE 727 (2002) [hereinafter Langleben et al., *Brain Activity*], (2) Tatia M. C. Lee et al., *Lie Detection by Functional Magneti Resonance Imaging*, 15 HUMAN BRAIN MAPPING 157 (2002), (3)

bilities taken the scientific community by storm, but they also have caught the attention of the lay press, which has produced some extraordinary headlines such as "Don't Even Think About Lying."[276] So convincing have these studies and their headlines been that private companies are now taking this technology and offering it to both the private and government sectors.[277] One company, Cephos Corp., currently offers this technology on its website.[278] The Cephos Corp is also associated with Dr. Frank A. Kozel of the Medical University of South Carolina, who has filed patent applications on this technology.[279] A federal district court for the State of Illinois may have handled the first case dealing with fMRI results in 2005, when the State offered it during its losing effort to fend off a First Amendment challenge.[280] Although the admissibility issues related to fMRI detection of neural activity in that case did not deal with fMRI lie detector technology directly, the gatekeeper found the fMRI testi-

Jennifer M. Nunez et al., *Intentional False Responding Shares Neural Substrates with Responses Conflict and Cognitive Control*, 25 NEUROIMAGE 267 (2004), (4) Langleben et al., *Telling Truth From Lie in Individual Subjects With Fast Event-Related fMRI*, 26 HUMAN BRAIN MAPPING 262 (2005) [hereinafter Langleben et al., *Telling Truth*], (5) Feroze B. Mohamed et al., *Brain Mapping of Deception and Truth Telling About an Ecologically Valid Situation: Function MR and Polygraph Investigation—Initial Experience*, 238 RADIOLOGY 679 (2006), (6) Ganis et al., *Neural Correlates of Different Types of Deception: An fMRI Investigation*, 13 CEREBRAL CORTEX 1047 (2003), (7) Spence et al., *Behavioral*, *supra* note 274, (8) Frank A. Kozel et al., *Brief Communications: A Replication Study of the Neural Correlates of Deception*, 118 BEHAVIORAL NEUROSCIENCE 852 (2004) [hereinafter Kozel et al., *Brief Communications*], (9) Frank A. Kozel et al., *A Pilot Study of Functional Magnetic Resonance Imaging Brain Correlates of Deception in Healthy Young Men*, J. NEUROPSYCHIATRY & CLINICAL NEUROSCIENCE 295 (2004) [hereinafter Kozel et al., *Pilot Study*], (10) Frank A. Kozel et al., *Detecting Deception Using Functional Magnetic Resonance Imaging*, 58 BIOLOGY PSYCHIATRY 605 (2005) [hereinafter Kozel et al., *Detecting Deception*], (11) Davatzikos et al., *supra* 88, and (12) Luan Phan et al., *Neural Correlates of Telling Lies: A Functional Magnetic Resonance Imaging Study at 4 Tesla*, 12 ACADEMIC RADIOLOGY 164 (2004)) (last visited Feb. 11, 2006).

[276] Steve Silberman, *Don't Even Think About Lying*, WIRED MAG., http://wired.com/wired/archive/14.01/lying_pr.html (last visited Feb. 21, 2006).

[277] *See id*. (discussing the two companies, No Lie MRI and Cephos Corp, that were due to offer fMRI lie detector services to the public in the spring of 2006).

[278] Cephos Corp., http://cephoscorp.com (last visited May 2, 2006) (containing website information that the corporation was founded in 2003 by Dr. Laken, who holds the exclusive world-wide license to commercialize fMRI lie detector technology, and also boasts that the technology has a ninety percent accuracy, and it is nonsubjective since humans do not ask questions or examine the scans and it uses validated algorithms).

[279] *See id*. (noting on their website that Drs. Andy Kozel and Mark George filed patent applications).

[280] *See Entm't. Software Ass'n*, 404 F. Supp. 2d at 1064.

mony unpersuasive.[281] Does this flurry of activity mean that fMRI lie detector results will pass admissibility challenges raised in either a *Frye* or *Daubert* jurisdiction?

Insight into answering this question must come from a review of the science and literature on this technology, not the hype associated with it. Although a total of twelve scientific articles have been published over the past six years, only three of these articles published, thus far, have reported accuracies related to deception detection, and they were: 90%,[282] 78%,[283] and 87.9%.[284] In fact, all but one of the twelve studies[285] utilized statistical parametric mapping paradigms to analyze fMRI data from groups of subjects.[286] Moreover, only five of these studies have even attempted to evaluate individ-

[281] *See id*. at 1067 (citing the testimony of the expert for the state as unpersuasive, where it did not provide a reasonable conclusion that experiencing a 'reduction of activity in the frontal lobes of the brain which is responsible for controlling behavior').

[282] Kozel et al., *Detecting Deception*, *supra* note 275, at 610 (presenting the results of their model building group (MBG, N=27 of 29 subjects) versus a model testing group (MTG, N=31 of 32 subjects), where an analysis of clusters of lie minus neutral for both groups and truth minus neutral for both groups was performed to identify clusters of activated voxels and average t values for different regions of the brain, which resulted in a ninety percent accuracy for the MTG group using analysis of clusters 1, 2, and 4 (cluster 1 = right anterior cingulated cortex, cluster 2 = right orbitofrontal cortex and inferior frontal cortex, and cluster 4 = right middle frontal cortex)).

[283] Langleben et al., *Telling Truth*, *supra* note 275, at 262 (reporting that a lie was discriminated from the truth in individuals on a single-event level with an accuracy of 78 percent, and a predictive ability of 85 percent, expressed as the percent area under the receiver-operator curve).

[284] *See* Davatzikos et al., *supra* note 88, at 666 (stating that a classification accuracy of 87.9 percent (90 percent sensitivity, 85.8 percent specificity) utilizing a high-dimensional non-linear pattern classification method as opposed to the standard statistical parametric mapping (SPM) method, which analyzes multi-subject average group difference in brain activation between truthful and untruthful respondents).

[285] *See id.* at 664 (using non-linear pattern classification).

[286] *See* Spence et al., *Behavioral*, *supra* note 275, at 2850 (stating that across group differences measured using SPM). *See also* Ganis et al., *supra* note 275, at 835 (2003) ("All the fMRI studies of deception conducted so far, including ours, have used group analyses . . ."); Langleben et al., *Brain Activity*, *supra* note 275, at 729 (stating in their methods section that analysis was performed to generate group SPMs); Lee et al., *supra* note 275, at 160 (stating in their section on methods that "averaged activation maps across subjects with a t-value threshold corresponding $P < 0.01$ were then overlaid on the corresponding T_1 weighted anatomical images"); Mohamed et al., *supra* note 275, at 683 (explaining that spatial parametric mapping 2 software was utilized to generate to form statistical parametric maps of the brain at the group level); Nunez et al., *supra* note 275, at 270 (explaining that data were analyzed using spatial parametric mapping 2 program, where group data were pooled and then analyzed).

ual differences among their test subjects, and of the five, three were published by the same group of investigators.[287]

Regardless of the statistical analysis technique, all fMRI investigators acquired their images using echo planar techniques. Moreover, all investigators noted increased activity during deception under echo planar imaging, whereas truth-telling demonstrated no activity in regions of the brain thought responsible for deception.[288] Unfortunately, not all of the published studies have shown the same one-to-one correlation of the areas of cortical activity associated with deception. Currently, most investigators have imaged activity primarily in the prefrontal cortical regions[289] or activation in orbitofrontal regions of the brain.[290] Some investigators now believe that the variations in activity, especially in regions of the ventrolateral prefrontal cortex, may be explained by either response reversal (alternate learning) related to the protocol utilized, or a neural inhibitory function, where the withholding of the truth by the subject is key to the experimental design.[291] Thus, the data from existing studies suggest that truth telling may be the baseline human response, as opposed to deception or lying, which is the variant response. Thus, the executive function regions of the cortical brain must rely on multiple cortical regions to successfully construct a deceptive response.[292] In fact, many of these same cortical areas are responsible for neural response inhibition and error monitoring.[293]

Even though the number of published studies on this technology continues to expand, several investigators have raised questions regarding the application of fMRI lie detection studies to the general

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[287] *See* Kozel et al., *Pilot Study*, *supra* note 275. *See also* Davatzikos et al., *supra* note 88, at 666; Kozel et al., *Brief Communications*, *supra* note 275, at 853; Kozel et al., *Detecting Deception*, *supra* note 275, at 606; Langleben et al., *Telling Truth*, *supra* note 275, at 270.

[288] *See* Spence et al., *Behavioral*, *supra* note 275, at 2850. *See also* Ganis et al., *supra* note 275, at 835; Kozel et al., *Pilot Study*, *supra* note 275; Kozel et al., *Brief Communications*, *supra* note 275, at 853; Kozel et al., *Detecting Deception*, *supra* note 275, at 606; Langleben et al., *Brain Activity*, *supra* note 275, at 729; Langleben et al., *Telling Truth*, *supra* note 275, at 270; Lee et al., *supra* note 275, at 160; Mohamed et al., *supra* note 275, at 683; Nunez et al., *supra* note 275, at 270.

[289] *See* Spence et al., *Behavioral*, *supra* note 275, at 2851; *see also* Ganis et al., *supra* note 275, at 833; Langleben et al., *Telling Truth*, *supra* note 275, at 270; Lee et al., *Lie Detection*, *supra* note 264, at 161; Nunez et al., *supra* note 275, at 270; Phan et al., *supra* note 275, at 167.

[290] Kozel et al., *Pilot Study*, *supra* note 275; Kozel et al., *Brief Communications*, *supra* note 275, at 855; Kozel et al., *Detecting Deception*, *supra* note 275, at 606; Langleben et al., *Telling Truth*, *supra* note 275, at 270.

[291] *See* Spence et al., *Behavioral*, *supra* note 275, at 2852.

[292] *See id*. at 1760.

[293] *See* Davatzikos et al., *supra* note 88, at 665.

population.[294] Some question whether private companies should make this technology available to the public, because most of the existing studies deal with comparisons between groups of subjects rather than evaluations of individual differences. Others question whether the current experimental design and testing procedures will translate to the general population, because most experiments do not emulate the high-stakes situations associated with deception, such as the loss of freedom.[295] Perhaps the greatest cause for concern comes from the realization that Dr. Frank A. Kozel, an fMRI lie detector patent applicant and a member of Cephos Corp., which offers fMRI lie detection services to the general public, has also emphasized the need for caution regarding the application of this technology to the general population.[296]

Based on the growing number of investigators raising concerns over the application of this technology to the general public, perhaps closer scrutiny of these studies is in order. Further examination of the existing fMRI lie detection or deception studies will likely reveal some interesting demographic differences between subjects studied and the general population. These differences should raise some fundamental concerns for those wishing to apply this technology to individuals within the general population. Taking into account all studies reported in the literature between 2001 and 2006, no more than 192 subjects have been scanned as part of fMRI deception detection experiments. Of the total number of subjects scanned, nearly 20% (38 of 192) of those initially enrolled in study groups were excluded due to motion artifacts or insufficient data. Of the subjects retained in their studies and analyzed, approximately 76% (117 of 154) were male, compared to only 24% (37 of 154) who were female.[297] These observations suggest that investigators may have unintentionally skewed their studies toward the male sex.

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[294] *See* Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1760–61; *see also* Davatzikos et al., *supra* note 88, at 665; Ganis et al., *supra* note 275; Kozel et al., *Brief Communications*, *supra* note 275, at 853.

[295] *See* Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1760; *see also* Kozel et al., *supra* note 275, at 612.

[296] *See* Cephos Corp., *supra* note 278.

[297] *See* Spence et al., *Behavioral*, *supra* note 275, at 2850 (reporting a study of ten male subjects in 2001); *see also* Davatzikos et al., *supra* note 88, at 663 (stating that the authors scanned twenty-two males only); Ganis et al., *supra* note 275, at 831 (stating that three males and seven females were enrolled, but three were excluded because their data was not recorded due to equipment problems); Kozel et al., *Brief Communications*, *supra* note 275, at 853 (scanning thirteen of fourteen subjects with only ten having usable data because three failed to lie as requested and of those scanned six were women); Kozel et al., *Pilot Study*, *supra* note 275, at 297 (reporting recruiting ten subjects with eight male subjects, but the

Surprisingly, no studies have looked for possible differences in the neural processes utilized by the sexes to commit deception during fMRI deception experiments. The absence of such studies is worrisome, since previous investigators have shown that anatomic differences exist between the male and female brains with fMRI.[298] If these apparent anatomical differences translate into functional differences in neural processing, it raises a question as to whether fMRI experimental findings related to deception or lie detection may be applicable to the general population, especially where women may be concerned. Perhaps the current groups studying fMRI have not considered the possibility that regional differences exist, and perhaps scientists have not studied this possibility because they have been focusing on group differences rather than individual ones. A less attractive possibility may be that current investigators have a bias toward male subjects, because they believe men are liars. Conversely, their bias might be directed against women, regardless of the propensity of this group to lie or not. Ultimately, only the scientists can know their motives, if any, for skewing studies toward

two females were excluded); Langleben et al., *Brain Activity*, *supra* note 275, at 728 (stating that twenty-three health subjects were enrolled and included twelve females and eleven males, but four had to be excluded due to motion artifact); Langleben et al., *Telling Truth*, *supra* note 275, at 263 (reporting scanning twenty-six males only); Lee et al., *supra* note 275, at 158–60 (noting the initial enrollment of six Chinese males, but only five were analyzed since one was excluded); Mohamed et al., *supra* note 275, at 683 (reporting that twelve participants were scanned, but one was rejected because the participant accepted guilt and of the eleven remaining subjects, six were males and five were female); Nunez et al., *supra* note 275, at 268 (indicating that twenty volunteers were enrolled in their study with the number divided equally among both sexes); Phan et al., *supra* note 275, at 167 (stating that they scanned fourteen subjects with seven females and seven males, respectively).

[298] *See* Ruben C. Gur et al., *Sex Differences in Temporo-limbic and Frontal Brain Volumes of Healthy Adults*, 12 CEREBRAL CORTEX 998, 1001 (2002) (observing differences in the regional volumes of the frontal lobes between the different sexes, where the women they studied had relatively larger orbitofrontal regions in their cortical brain as compared to their male subjects, which suggested to the authors that further studies were warranted, because these regions are critical to social behavior, emotional function, and cognitive skills, such as reasoning and decision making); *see also* Jill M. Goldstein et al., *Normal Sexual Dimorphism of the Adult Human Brain Assessed by In Vivo Magnetic Resonance Imaging*, 11 CEREBRAL CORTEX 490, 493–95 (2001) (finding results of their study replicate those of existing studies, which show the brain of normal males is larger than the female brain, but this sexual dimorphism is not spread through the brain, which may be in part due to hormonal differences between the sexes); Ruben C. Gur et al., *Sex Differences in Brain Gray and White Matter in Health Young Adults: Correlations with Cognitive Performance*, 19 J. NEUROSCIENCE 4065, 4070 (1999) (demonstrating on MRI studies of the brains of both sexes that women have a higher percentage of gray matter overall, when compared to men, who have a higher percentage localized to their left hemisphere, which suggests the small crania of women enable them to utilize their white matter more efficiently than men, and it also may explain why women may perform better on verbal tasks than spacial tasks when compared to men).

male subjects. Unfortunately, these observations are very likely to cause admissibility problems for those wishing to introduce fMRI deception detection testimony or results into evidence under the *Frye* test, or under *Daubert* and its progeny in the near future.

A. Based on the Existing Study Data, fMRI Lie Detector Results Will Not Pass *Frye*.

To be admissible in a *Frye* jurisdiction, fMRI lie detector results must be generally accepted by the relevant scientific community.[299] According to the dicta set forth by the Supreme Court in *Scheffer*, regarding the disagreements among jurisdictions on whether to admit polygraph evidence,[300] the question may be unanswered with respect to fMRI lie detector results since the courts lack an extensive history with this technology. Moreover, the physiological responses that the two technologies detect, as indicators of deception, are different.[301] Unlike the polygraph, which measures sympathetic nervous system discharge, fMRI detects alterations in cerebral blood flow related to the BOLD effect, which indirectly reflects increased neuronal activity that can be displayed as a map of brain function.[302] Moreover, courts tend to mistrust the reliability of the polygraph because it indirectly measures deception and is prone to countermeasures.[303] If fMRI can be shown to be more reliable than polygraph, then it may increase the likelihood that courts will admit it into evidence. Even so, fMRI deception technology has its limitations, including the lack of testing in an actual crime situation,[304] and a lack of consistent identification of specific regions associated with deception across the different studies.[305] Again, several authors have raised concerns related to lack of their ability to identify spe-

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[299] Bohan, *supra* note 148, at 108.

[300] *See Scheffer*, 523 U.S. at 303, 310 (discussing the lack of consensus among the state and federal courts regarding the admissibility and the reliability of the polygraph, and noting that under *Frye* the state and federal courts should have a universal bar against the polygraph).

[301] Mohamed et al., *Brain Mapping*, *supra* note 275, at 680 (discussing the differences between the polygraph and fMRI technology and the responses they detect where the polygraph measures sympathetic nervous system discharge related to fear, which may or may not be the result of deception or lying).

[302] *Id.* at 680.

[303] *See* discussion *supra* Part III.A. for an explanation of the physiology and problems associated with deception detection utilizing the polygraph.

[304] Ganis et al., *supra* note 275, at 835.

[305] Nunez et al., *supra* note 275, at 267 (noting that multiple studies have identified various regions of the brain with activity associated with deception that include the frontal, parie-

cific regions of the brain associated with deception in a given individual.[306] Because this technology continues to evolve, these issues may be resolved as newer statistical programs and refinements to the existing technology come online. Even so, any fMRI lie detection testimony or evidence proffered in a *Frye* jurisdiction will have to be generally accepted by the relevant scientific community.

The first question a *Frye* court will have to answer is who qualifies as the relevant scientific community for the determination of the general acceptance issue. In the case of fMRI lie detection technology, the answer to this question may not be readily apparent. For example, the majority of centers working with this technology involve multiple disciplines that include psychiatry, psychology, neuroscience, and diagnostic radiology. If one or more medical disciplines are actively involved in this research, then what criteria will the court use to determine who has the authority or expertise in this field? If one goes by the primary focus of the journals in which fMRI lie detection articles are published, one will find publications have been spread throughout a variety of journals within these fields. To date, five of the thirteen articles in the literature have been published in journals focusing on radiological imaging,[307] whereas the remaining articles have been split between journals related to neuroscience, psychiatry, and psychology.[308] Because fMRI technology is highly technical, requires a technical understanding of MR physics, relies on an evaluation of anatomical images, and is published in the radiology literature, then perhaps, a gatekeeper faced with identifying the relevant scientific community will choose the field of radiology. Conversely, the subject also requires an understanding of neurophysiology and psychology, and many of the current authors and coauthors on this topic are psychiatrists, neuroscientists, and psychologists. Therefore, one of these disciplines may be classified as the relevant community. It is likely any

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tal, and temporal cortices, and more importantly these regions vary across studies suggesting a lack of consistency).

[306] *See* Kozel et al., *Detecting Deception*, *supra* note 275, at 605 (noting that many studies prior to 2005 only evaluated between group differences, not individual differences).

[307] Nunez et al., *supra* note 275, at 270; *see also* Davatzikos et al., *supra* note 88; Langleben et al., *Brain Activity*, *supra* note 275, at 729; Mohamed et al., *supra* note 275, at 683; Phan et al., *supra* note 275, at 167.

[308] Ganis et al., supra note 275. *See also* Critchley et al., *Neural Activity Relating to Generation and Representation of Galvanic Skin Conductance Responses: A Functional Magnetic Response Imaging Study*, 20 J. NEUROSCIENCE 3033 (2000); Kozel et al., *Pilot Study*, *supra* note 275; Kozel et al., *Detecting Deception*, *supra* note 264; Kozel et al., *Brief Communications*, *supra* note 275; Spence et al., *Behavioral*, *supra* note 275.

trial judge facing this issue will have to determine, through testimony, who qualifies as the relevant scientific community.

For the sake of argument, suppose the court decides the discipline of radiology is the relevant community, then the court must move through the next layers of analysis. A court following *Frye* must now ask whether the doctrine or theory underlying the science of fMRI has general scientific acceptance within the radiology community.[309] It is very likely that a court analyzing such a question will find that the doctrine or theory of fMRI is well accepted by the radiology community.[310] The next level of inquiry for the court will be whether the technique of fMRI lie detection enjoys general acceptance within the relevant community. It may be too early in the development of this aspect of the fMRI studies to know whether the radiology community accepts the technique of fMRI lie detection.[311] Based on the reservations about readiness of this technique for practical application within the general population, it may be safe to say that a general consensus is lacking.[312] If the court makes it beyond the question of acceptance of the technique within the relevant community to the application of the technique by a particular individual, then the answer may well depend on the study done. Remember, only five studies have even attempted to look at deception within the individual, which means the majority of studies have only looked at group differences, not individual differences.[313] Again, only three studies have actually published their accuracies related to detection of deception within a given individual.[314] Based on the existing published research, it would seem unlikely that a court in a *Frye* jurisdiction would admit fMRI lie detector results, unless the expert proffering the testimony or results could show that individual differences were evaluated.

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309 *See* Bohan, *supra* note 160, at 109 (discussing the *Frye* I question).

310 HUETTAL ET AL., *supra* note 90, at 11 (discussing the history of fMRI beginning with the first phase of development of the physics of magnetic resonance imaging to stage five where the BOLD effect and changes in blood flow could be detected with MRI in the 1990s).

311 *See* Bohan, *supra* note 160, at 109 (discussing the *Frye* II question, where the court looks at the acceptance of a particular technique within the relevant scientific community).

312 *See* Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1760; *see also* Kozel et al., *Detecting Deception*, *supra* note 275, at 612.

313 *See* Kozel et al., *Pilot Study*, *supra* note 275, at 295; *see also* Kozel et al., *Brief Communications*, *supra* note 264, at 855; Kozel et al., *Detecting Deception*, *supra* note 275, at 605; Langleben et al., *Telling Truth*, *supra* note 275, at 270.

314 *See* Kozel et al., *Detecting Deception*, *supra* note 275, at 610; *see also* Davatzikos et al., *supra* note 88, at 666; Langleben et al., *Telling Truth*, *supra* note 275.

B. *Daubert* and Its Gatekeeper Are Unlikely to Admit fMRI Lie Detector Results.

According to the Supreme Court in *Daubert*, the adoption of Rule 702 should allow for a fair and flexible evaluation of novel scientific evidence, and therefore permit more evidence to be admitted.[315] In practice, however, the inquiry may not be as flexible as the Court originally intended, since some commentators have published results that suggest novel evidence is likely to be rendered inadmissable.[316] As discussed earlier in this article, both the polygraph and brain fingerprinting technologies have had their troubles with the gatekeeper when it comes to admissibility under *Dauabert*.[317]

If a court is faced with fMRI lie detector deception test results, then it will evaluate the fMRI expert and the test. First, it will determine whether the subject matter of the fMRI expert pertains to scientific knowledge.[318] In the case of fMRI lie detector test results, a court will likely have no trouble determining that the results and any testimony about them pertain to scientific knowledge. Next, a court will review validity of the methodology of fMRI lie detection by examining whether the principles underlying fMRI lie detection support what they are purported to show. Then it will review the application of the methodology of the fMRI lie detector test for production of consistent results as evidence of its reliability.[319] To assist with this portion of the evaluation, a court will run through the nonexclusive factors provided by the Court in *Daubert* that include: (1) whether the theory or technique has or can be tested (falsifiability), (2) whether the theory or technique has been subjected to peer review and publication, (3) whether the scientific technique has a known or potentially known rate of error, and (4) whether the theory or technique is generally accepted, or whether it has only a minimum of support.[320] Finally, a court will assess the intellectual

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[315] *See Daubert*, 509 U.S. at 594–95 (emphasizing that the inquiry under Rule 702 should be a fair and flexible one with its "overarching subject is scientific validity—and thus the evidentiary relevance and reliability—of the principles that underlie a proposed submission.").

[316] *See supra* note 188 and accompanying text explaining that a *Daubert* challenge to novel scientific evidence generally results in summary judgment in favor of the party opposing the evidence, which has been the trend since the Court adopted Rule 702.

[317] *See supra* notes 232 and 273 and accompanying text, explaining the reluctance of courts to admit results from the polygraph and brain fingerprinting tests, respectively.

[318] *See supra* notes 173-82 and accompanying text.

[319] *See supra* notes 173-82 and accompanying text.

[320] *See supra* notes 174-86 and accompanying text.

rigor utilized in the methodology, and it will not accept any "analytical gaps" in the analysis of the expert, where the methodology must fit the facts of the instant case.[321] These questions are addressed next.

C. fMRI Lie Detection Evidence Must Pass Through the Gates of *Daubert.*

1. *Can fMRI Lie Detector Science Be Tested?*

The answer to this question is yes, but this "yes" answer may be a qualified one, which only begins the inquiry into the admissibility of fMRI testimony or results. As discussed in previous sections of this article, fMRI lie detection technology is evolving and most of the research data in the literature is derived from experimental studies. Currently, the literature contains only twelve published studies related to the fMRI lie detector test, and considering all the studies to date, a mere 192 subjects have been studied, consisting primarily of males.[322] Furthermore, the total number of publications related to fMRI lie detection is much less than the existing body of scientific literature related to polygraph technology,[323] or brain fingerprinting technology.[324] Moreover, the existing studies have utilized different experimental paradigms to test for deception in their subjects with fMRI. Although many of the existing studies have detected activity in particular regions of the brain, some investigators worry that the existing studies are highly variable, and do not show the necessary consistency in linking particular areas with deception.[325]

Obviously, this technology and its associated technique is in its developmental stage, but unlike the polygraph test, the physiologic responses being measured are known.[326] Although the physiological events of the BOLD effect are known, fMRI detection of any changes in BOLD effect within a given region of the brain only indirectly

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[321] *See supra* notes 180-88 and accompanying text.

[322] *See supra* notes 297-98 and accompanying text.

[323] NAT'L RESEARCH COUNCIL, NAT'L ACADEMIES, *supra* note 198 (explaining that only fifty-seven studies were available that formally address the accuracy of the polygraph test).

[324] *Publications*, *supra* note 269.

[325] Nunez et al., *supra* note 275, at 267 (noting that publications prior to 2004 identified activity in a variety of locations that included the frontal, parietal, and temporal lobes, but the areas were highly variable and lacking in consistency in areas of activation, which may have been due to the large variability in their experimental designs and the use of broad and behaviorally complex definitions of the deceptive acts).

[326] *See* Mohamed et al., *supra* note 275, at 680.

measure neuronal activity.[327] Successful detection of this activity also requires a willing subject since any movement from an uncooperative subject may destroy the use of any data acquired.[328] Thus, fMRI lie detection technology may not have reached a state of perfection.[329]

If the reasoning of the Court in *Scheffer* is a guide, as it is for many federal courts adhering to *Daubert*, then these issues may undermine the validity of fMRI methodology in its current form.[330] Because *Scheffer* deals with military rules and law, many courts find its rationale and discussion "germane" to civilian cases.[331] Courts tend to view polygraph science as developing and inexact, where there is no way to know whether the conclusions reached by the polygraph expert are accurate because of the inherent uncertainties.[332] Unless future fMRI lie detector experiments can show that the technology consistently identifies specific areas of brain activity and is not subject to defeat, courts may be unwilling to affirm it.

2. *Has fMRI Lie Detector Science Passed Peer Review?*

Clearly, the answer to this second question should be yes, since twelve articles have been published in peer-reviewed literature over the past six years.[333] As with any theory, the more it has been pub-

[327] *See id.*

[328] Kozel et al., *Detecting Deception*, *supra* note 275, at 606 (pointing out that the technique of fMRI lie detection requires a willing subject who, if unwilling, may defeat the test by refusing to answer questions, answering randomly to questions, move his or her head, or refuse to enter the scanner).

[329] *See* Yongender S. Bansal et al., *Recent Advances in Lie Detection*, 26 J. INDIAN ACAD. FORENSIC MED. 27, 28 (2004) (noting that fMRI remains in a state of infancy and more research is needed, which incorporates varying demographic profiles of individuals in order to broaden the base for comparison and for corroboration of brain patterns that are predictive of truth telling as opposed to those predictive of deception).

[330] *See Scheffer*, 523 U.S. at 312 (discussing the variability among the different jurisdictions regarding the science of the polygraph test where courts question whether the polygraph had reached a sufficient state of reliability to be admissible).

[331] United States v. Zambouros, 338 F. Supp. 2d 460, 463–64 (S.D.N.Y. 2004) (citing the rationale and discussion by the Court in *Scheffer* as compelling and germane to civilian criminal cases, and stating that many federal courts follow its reasoning in doubting the reliability of polygraph evidence because the scientific community is extremely polarized about it and because there is no way to know if it is accurate).

[332] United States v. Henderson, 409 F.3d 1293, 1303 (11th Cir. 2005).

[333] Langleben et al., *Brain Activity*, *supra* note 275; *see also* Ganis et al., *supra* note 275; Kozel et al., *Brief Communications*, *supra* note 275; Kozel et al., *Pilot Study*, *supra* note 275, Kozel et al., *Detecting Deception*, *supra* note 275; Langleben et al., *Telling Truth*, *supra* note 275; Lee et al., *supra* note 264; Mohamed et al., *supra* note 275; Nunez et al., *supra* note 275; Spence et al., *Behavioral*, *supra* note 275.

lished and discussed within a scientific community, the more likely a court is willing to accept it.[334] Based on the small number of publications currently in the literature, as compared to those addressing the polygraph and brain fingerprinting tests, it is likely that fMRI will pass this factor, but only barely. This factor, however, is not fatal to the inquiry, since it does not necessarily correlate with reliability.[335]

3. *Is the Error Rate For the fMRI Lie Detector Test Known?*

The answer is yes, but it may not be sufficiently evaluated for a court to accept it. Most of the currently published studies look at group differences, not individual differences.[336] Only three studies have published their accuracies, which range from seventy-eight to ninety percent.[337] The number of subjects actually evaluated within these three studies ranged from twenty-two to thirty-one or a total seventy-nine individuals.[338] These accuracies may not necessarily pass the test of the Supreme Court in *Scheffer*, where it made polygraph test accuracy an issue, noting that rates that varied from fifty to eighty-seven percent.[339] More importantly, the Court found no consistently reliable reports on the accuracy of the polygraph technology, and its concern was mirrored by the report published by the National Academies.[340] Another issue related to the establishment of an error rate, which could influence results, may be the lack of specific protocols.[341] Interestingly, the lack of uniform standards has

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[334] *See* Gallai et al., *supra* note 192, at 96.

[335] *See Daubert*, 509 U.S. at 593.

[336] *See supra* note 286 and accompanying text.

[337] *See supra* notes 282-84 and accompanying text.

[338] *See* Kozel et al., *Detecting Deception*, *supra* note 275, at 606 (noting that they scanned thirty-one subjects without formally identifying the sex of their subjects); *see also* Davatzikos et al., *supra* note 88, at 664 (identifying the number of subjects scanned as twenty-two males); Langleben et al., *Telling Truth*, *supra* note 275, at 262 (denoting that they scanned twenty-six males).

[339] *See Scheffer*, 523 U.S. at 310.

[340] *See* NAT'L RESEARCH COUNCIL, NAT'L ACADEMIES, *supra* note 196 and accompanying text.

[341] *See* Spence et al., *Cognitive Neurobiological*, *supra* note 2, at 1760 (outlining the issues related to the brain and law where potential problems foreseen by the authors included: (1) ecological validity where experiments involved compliant individuals who were not involved in high stakes situations, (2) experimental design consists of simple deception experiments which have fairly obvious discriminators of truth versus lie to analyze simple situations, but ones not mirroring the real world, (3) potential lack of statistical power where studies to date have shown conclusively deception within an individual where a range of differences may exist, and (4) whether deliberate deception could be a normal response for some individuals).

been fatal in the case of polygraph testimony.[342] It is too early to say whether the current accuracies and procedures associated with fMRI are absolutely fatal. However, it is likely that they are until more studies accrue.

4. *Is fMRI Lie Detector Science Generally Accepted?*

This analysis has been assessed already in section III dealing with the general acceptance test under *Frye*. Clearly, the science of this technology is subject to debate even among those who are its greatest advocates.[343] Whether this technology is generally accepted may well depend on the relevant community the court chooses.[344] Moreover, a court will have to analyze the general acceptance of theory and its application to a particular individual.[345] If the answer is "no" under *Frye*, then analysis under this factor for *Daubert* is likely to result in a "no" answer as well.

D. The "Analytical Gap" from the Experimental to the Practical Application of fMRI Lie Detection Technology May Be Too Great.

The Supreme Court, in *Joiner*, recognized the existence of a relationship between the methodology employed by experts and their conclusions.[346] In effect, the Court shifted the focus in *Daubert* from one solely on the methodology of a given expert, to one that examines the linkage between the methodology utilized by the expert and the conclusions reached using that particular methodology.[347] Moreover, the Court emphasized that the "gatekeeper" has the responsibility of ensuring that the expert can explain the requisite steps of their methodology to assist the trier of fact, and that the

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342 Gallai, *supra* note 192, at 99.

343 *See supra* notes 299–308 and accompanying text.

344 *See supra* notes 308–309 and accompanying text.

345 *See supra* notes 299–306 and accompanying text.

346 *Joiner*, 522 U.S. at 146 (stating that "conclusions and methodology are not entirely distinct" from each other, and that a trial judge need not admit evidence solely based on the "*ipse dixit*" of the expert, where the trial judge may conclude that "too great an analytical gap" exists between the "data and proffered opinion").

347 Theresa M. Moore, Note, *Closing the Doors on Unsupported Speculation: Joiner's Effect on the Admissibility of Expert Testimony*, 33 IND. L. REV. 349, 383 (1999) (explaining that the Court in *Joiner* recognized that experts extrapolate conclusions from their data, and courts need not admit data based upon the expert, as an authority figure, but should look for the proper linkage between the underlying data and the ultimate conclusion derived from its analysis).

methodology also fits the relevant facts of the case.[348] Not only can the court examine the accuracy of an expert's conclusion, but the gatekeeper also can determine the "fitness of the proffered testimony" to facts of the case.[349] Thus, the gatekeeper is given much greater discretion to limit the admissibility of evidence on a "weight-of-the-evidence" approach; the gatekeeper may exclude evidence based on her opinion that the "analytical gap" between the expert's opinion and the data is too great.[350]

fMRI lie detection studies, thus far, have been based on controlled experiments. Any expert proffering testimony related to the acquisition of results from true life situation will have to bridge the "analytical gap" between the experimental and the true life situation. More importantly, the expert will have to show that her conclusions fit the facts of the individual case. It is highly likely that any expert testimony on the current state-of-the-science of fMRI lie detection will be vulnerable to attack on several methodology issues.

These methodology issues flow from variations in the experimental designs of many studies.[351] Most of the studies in the literature that evaluate differences in brain activity related to deception do so across a given group of subjects rather than focusing on a particular individual or subject.[352] Moreover, many of these same studies identify multiple areas of activity that are attributed to the act of deception.[353] These differences in activity may be related to the different experimental designs used to test the process of deception in experimental subjects.[354] For example, increased activity in the ventromedial portions of the prefrontal cortex and medial prefrontal cortex may be related to the neurological processes needed to create deceptions related to autobiographical questions, whereas other areas may be strongly active when a subject must answer questions related to guilty knowledge.[355] Any expert wish-

[348] *See id.* at 383.

[349] *See id*. at 382.

[350] *See id*. at 382–88.

[351] *See supra* note 297 and accompanying text.

[352] *See supra* text accompanying notes 286–88.

[353] *See supra* text accompanying notes 288–91.

[354] *See* Kozel et al., *Detecting Deception*, *supra* note 275, at 611 (discussing the between study differences related to the identification of areas of activation, which may be related to the types of tasks utilized to test deception that involve different types of lies).

[355] *See* Phan et al., *supra* note 275, at 165.

ing to extrapolate findings from an fMRI lie detection study must account for these methodological differences.

The inability of an expert to speak to individualized findings has been addressed recently by one federal court. In *Entm't Software Ass'n*, the court specifically focused on the testimony of two experts regarding fMRI studies of brain activity in adolescents exposed to high and low levels of media violence.[356] In that case, the defense expert testified that his research on fMRI detection of activity in different areas of the brain related to high and low levels of violence.[357] The opposing expert did not dispute the findings of the defense expert but attacked the methodology utilized to conduct the experiment and its findings.[358] The expert also presented plausible alternative explanations for the findings observed in the fMRI experiments.[359] The court concluded, based on the testimony given by both experts, that fMRI results were not credible and the studies did not support the weight the expert placed on those studies.[360] If the treatment of expert testimony related to fMRI studies is any indication of the treatment awaiting fMRI lie detection studies, courts are unlikely to admit this evidence or find it credible based on the "analytical gap" and lack of fitness to the individual case.

[356] *See Entm't Software Ass'n*, 404 F. Supp. 2d at 1066 (discussing the testimony of an expert who challenged the results of an fMRI scan where the expert explained that the studies are composite images of all the individuals within a study, and such studies "can show activity in areas where no individual subject showed activity").

[357] *See id.* at 1064 (citing an expert for the defense who conducted and published a study in a peer-reviewed journal, which examined how exposure to media violence affects aggressive thinking and aggressive behavior in adolescents. The study also showed activity differences in fMRI studies where two groups of adolescents were studied using a Stoop test, in which differences were detected between controls and adolescents with behavior disorders (controls showing anterior cingulated cortex and left dorsolateral prefrontal gyrus versus those with behavior disorders demonstrating activity in the medial frontal gyrus of the dorsolateral prefrontal gyrus but no activity in the anterior cingulated cortex). Similar patterns were showed in adolescents exposed to high media violence as opposed to adolescents exposed to low media violence, which showed activity in the anterior cingulated cortex and left inferior frontal gyrus.).

[358] *See id.* at 1066 (citing rebuttal testimony of the expert for the plaintiff who attacked the methodology of the expert for the defense by stating that images were composite images of all the individuals where no single may have shown activity, noting that the tests utilized were not appropriate, and comparing the "many-to-many relationships" between brain regions and behavior did not allow for "clear kinds of inferences" made by the defense expert).

[359] *See id.* at 1067.

[360] *See id.* at 1061–67.

V. CONCLUSION

FMRI has the potential to unlock the secrets of the mind. Utilization of the BOLD effect continues to reveal areas of activity within the brain. Although these areas of signal intensity are said to represent brain activity, they actually indirectly measure the activity of neurons because they measure changes in *deoxyhemoglobin* levels. Even so, investigators have been able to detect areas of the brain that are involved in deception. To be sure, deception is a complex process that involves the executive function regions of the brain, primarily the prefrontal cortex, and to a lesser extent, the parietal and temporal regions of the brain. Not only do the current investigators recognize the potential of fMRI, but entrepreneurs and the government also see its potential impact in the courts and in the global war on terrorism. However, the current technology is still in its experimental stage, even though some wish it were otherwise. As these parties push this technology forward, it is bound to enter the courtroom, probably sooner rather than later. The question is whether the gatekeeper is prepared to meet the challenge. Perhaps the more appropriate question is whether the technology and its experts are ready for gatekeeper.

The current state-of-the-art for fMRI lie detection is too premature to be admitted into the courtroom as evidence. Too few studies have been performed evaluating individual differences. Only five of the twelve scientific studies currently in the literature have attempted to evaluate activities within the brain of a given individual, and one of these found too much variability to be useful. More importantly, only three of these five studies actually calculated test accuracies. To date, probably the most crucial revelation is that none of these studies attempted to detect deception in a live situation where the risks are high. Some studies are now evaluating mock crimes and subjecting subjects to risks-reward situations. Are these really high-risk situations? What constitutes high risk? It is unlikely that any gatekeeper is going to admit fMRI evidence, regardless of the jurisdiction. Would a reasonable person want to have his or her freedom or job contingent on the results of fMRI lie detector technology? Odds are the gatekeeper, regardless of jurisdiction, will say no. This is the proper conclusion until more work is done with this technology.