The Realities of Neurolaw: A Composition of Data & Research

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"Matching neurological data to legal criteria can be much like performing a chemical analysis of a cheesecake to find out whether it was baked with love."\(^1\)

**INTRODUCTION**

The purpose of the law is to protect the interests of society, and promote justice. The following paper explores how the interests of justice are challenged and strengthened by the introduction of interdisciplinary research. Today the integration of law and neuroscience is at the forefront of legal admissibility. Cognitive neuroscience has the potential to contribute a great deal to the legal profession, but the question is whether neuroscience is prepared to make those contributions *right now*.\(^2\) In order to answer this question, medical researchers, scholars, and legal professionals need to gauge whether neuroscience can measure criminal responsibility. To begin the process researchers must first "clarify legal criteria for criminal responsibility,"\(^3\) and then determine how neurological findings can be used to demonstrate cohesion to the criteria. The visionaries in each perspective field have the ability to guide new medical techniques, which have the power of influence over the law and future public policy. This study examines a sample of neuroscientific and legal literature, and follows with a comparative study of DNA and neuroimaging evidence.

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3. Aharoni et al., *supra* note 1, at 145.
I. LITERATURE REVIEW

By the end of the twentieth century technological advancements had been made which redefined research methods applied to study cognitive decision-making processes. Researchers are fueled by the potential relationship between neuroscience and law. Attorney J. Sherrod Taylor introduced the term “neurolaw” in 1995 when he explored the possible influence neuroscientific evidence could have on civil litigation. Neuroscience, in the realm of neurolaw, is the study of the “central and peripheral nervous system” with a focus on the structural composition and function of the brain in relation to action and decision-making. Research is triggered by the beneficial relationship of cognitive neuroscience capabilities as tools to increase efficiency and knowledge in the courtroom. Author Luca Arnaudo assessed the following as the tasks assigned to cognitive law research:

(1) A better understanding of individual personality as related to the subject’s ability to react in order to assess his responsibilities (not exclusively the ones having penal relevance); (2) a strengthening evidence related to the individual ability to act; (3) an improvement of legal drafting and of the application of legislative and statuary provisions, in light of a better knowledge of reactions to said provisions under a cognitive-behavioral profile.

Researchers in the neurosciences and law hope to expand the tool chest available to evaluate a defendant’s criminality. They are also working to identify the factors that contribute to developing a cognitive blueprint of a person’s blameworthiness. Those involved are assessing whether current neurological methods will assist decision makers in making judgments about criminal liability.

Neuroimaging, such as Magnetic Resonance Imaging, may help scientists identify deceptive behavior and testimony. Unlike a polygraph test, neuroscience could potentially provide a more reliable method of deception interpretation. Researchers hope that the introduction of

4. Arnaudo, supra note 2.
7. Arnaudo, supra note 2, at 1.
8. Id. at 8.
neuroscience and brain analysis in the courtroom will better assist legal and medical professions in assessing future danger posed by an individual and the likelihood of recidivism.

Cognitive research to date has been able to develop a keener understanding of cognitive ability and the human decision-making process.\textsuperscript{10} Neuroimaging analysis is subjective and influenced by physician decision-making regarding technique and interpretation.\textsuperscript{11} Because the analysis of neuroimaging is subjective, developing a guide to determine which types of imaging studies can be used, and how each image should be read, will provide consistency in future utility. Additionally, criminal responsibility is used in many different contexts, and this context differentiation seems to indicate “a syndrome of concepts” rather than a “generic concept.”\textsuperscript{12} Given criminal law’s diverse responsibilities component, researchers should be wary of confiding in a very basic level of brain imaging to answer the question of responsibility.\textsuperscript{13}

II. A SYMBIOTIC RELATIONSHIP

Scholars in the field of neurolaw have focused their analytic and scientific energy on “expected developments and risks caused by the introduction of biometric technologies developed in the field of neuroscience in trial dynamics, especially regarding evidence examination in criminal trials.”\textsuperscript{14} A better understanding of neuroevidence could allow judges to better gauge what evidence should and should not be admitted in various criminal contexts. By clearly understanding the tools used to map brain imaging, judges and jurors have a better chance of advanced and correct interpretation. In order for neurolaw to become a reality its methods must follow recognizable guidelines that can be properly applied to a legal process.

The Federal Rules of Evidence have developed guidelines for assessing the reliability and admissibility of scientific evidence, thus already limiting the scope of neurolaw. For example, in order for evidence to be admissible in a courtroom its probative value must outweigh its prejudicial value, i.e. the evidence must be able to provide enough information to establish facts in the case.\textsuperscript{15} To achieve successful interpretation neurolaw must create a standard by which to judge a defendant’s neuroimaging to determine

\textsuperscript{10} Arnaudo, supra note 2.
\textsuperscript{11} Shafi, supra note 9.
\textsuperscript{12} Nicole Vincent, On The Relevance Of Neuroscience To Criminal Responsibility, 4 CRIM. L. PHIL. 77, 82 (2009).
\textsuperscript{13} Id.
\textsuperscript{14} Arnaudo, supra note 2, at 5.
\textsuperscript{15} Shafi, supra note 9.
whether the legal requirement has been met.\(^\text{16}\)

**A. Frye, Daubert, and the Federal Rules of Evidence.**

In the interest of justice, the United States Congress developed a set of federally established rules whereby attorneys and judges present evidence to a jury in a courtroom; these are commonly referred to as the Federal Rules of Evidence. In addition to the Federal Rules of Evidence, two seminal cases shape admissibility of scientific evidence in the United States.

The first case is *Frye v. United States*, where defendant, James Alphonso Frye, was convicted of murder in the second degree and appealed the court’s decision.\(^\text{17}\) The court in *Frye* determined that expert testimony based on scientific technique was admissible when the technique was a generally accepted practice in the corresponding scientific community.\(^\text{18}\) The court reached this decision after weighing and rejecting the admissibility of polygraph evidence in the courtroom. The rule also extends to scientific procedures and principles presented during trial. The *Frye* standard, though instructive, is not determinative and is only adhered to by a handful of states.

The other seminal case in establishing scientific evidence is *Daubert v. Merrell Dow Pharmaceuticals*. The *Daubert* case involved parents initiating a suit against Merrell Dow Pharmaceuticals, alleging the company’s drug, Bendectin, caused birth defects in their children.\(^\text{19}\) The *Daubert* standard, created in 1993, states that the enactment of the Federal Rules of Evidence precedes the *Frye* standard.\(^\text{20}\) The court determined since the Federal Rules of Evidence were created in 1972, and superseded *Frye*, *Frye* was no longer the national standard.\(^\text{21}\) Additionally, the court generated a list of factors to consider when weighing scientific evidence including:

1. whether the theory or technique is testable;
2. whether the theory or technique has in fact been tested;
3. whether the theory or technique has been subjected to peer review and publication;
4. what is the known or potential error rate;
5. whether there has been an ‘existence and maintenance of standards controlling the

\(^{16}\) Aharoni et al., *supra* note 1.

\(^{17}\) *Frye v. United States*, 293 F. 1013 (D.C. Cir. 1923).

\(^{18}\) Id.


\(^{20}\) Id.

\(^{21}\) Id.
technique’s operation’; and (6) whether the theory or technique has attained general acceptance.²²

Neuroimaging evidence will be scrutinized under these standards as well as the Federal Rules of Evidence. Arguably, neuroimaging fulfills many of the Daubert factors, but the lack of standardization weakens potential admissibility.

In addition, the Federal Rules of Evidence provide two rules that will play substantial roles in the admissibility of neuroevidence. The rules state that only evidence relevant and probative is admissible in court. Federal Rules of Evidence §401, Test for Relevant Evidence, states: Evidence is relevant if: “(a) it has any tendency to make a fact more or less probable than it would be without the evidence; and (b) the fact is of consequence in determining the action.”²³ The rule that supplanted the Frye standard states:

A witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if: (a) the expert’s scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue; (b) the testimony is based on sufficient facts or data; (c) the testimony is the product of reliable principles and methods; and (d) the expert has reliably applied the principles and methods to the facts of the case.²⁴

Each rule is directive in admitting scientific evidence for trial, and supplemented by drafter commentary on admissibility in certain instances. Although neuroscientific evidence is not presently included in the commentary section, due to its current unorthodox use, a reframing of neuroscientific trial presentation may influence a rule change. A handful of courts have already attempted to establish this framework.

B. Limited Legal Precedent

Neurolaw, still in its infancy, has received some practical recognition in the courtroom. For instance, neuroimaging played a significant role in determining the wishes of Terri Schiavo in the Schiavo case.²⁵ The case involved a legal struggle over the prolonged life support of Teresa Marie Schiavo from 1990 to 2005. Terri’s husband, Mr. Schiavo, was focused on terminating life support once his wife was diagnosed as living in a

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²⁵ Annas, supra note 5.
persistent vegetative state. The case was highly publicized and prolonged by a legal feud between Mr. Schiavo and the legislature. This intervention led to a seven-year delay before her life support was terminated. Two pieces of evidence played a significant role in determining Terri Schiavo’s case, (a) a videotape taken of Terri Schiavo as she lay in the hospital, and (b) a Computerized Tomography scan of Terri’s brain. The tape showed Terri smiling when her family or husband entered the room, which suggested non-vegetative responses. But the scan of Terri’s brain, coupled with expert testimony from neurologists and Terri’s doctors, convinced the appellate court that Terri’s vegetative state was irrefutable.26

In 2005, the Supreme Court in Roper v. Simmons determined that anyone under the age of eighteen is exempt from the death penalty. Many analysts believed that the verdict stemmed from medical associations and scholars, which presented evidence proving that brain peculiarities in minors may influence their behavior.27 The neurological evidence in this case stated that brain development takes place in stages, and the prefrontal cortex, which regulates decision-making and judgment, is one of the last parts of the brain to fully mature.28 Additionally, the limbic system, which processes and manages emotions, is also developing during adolescence.29

In 2007 a Pennsylvania appellate court found itself diminishing the death sentence of a criminal, to life in prison, after neurological evidence surfaced showing abnormalities in the criminal’s frontal lobes.30 The judge was persuaded to rule against the death penalty because the defendant was unable to function normally due to the aberrations in his brain.31

Additionally, the McMurtey v. Ryan court used expert testimony and brain imaging to prove that a defendant was incompetent to stand trial for the murder of two men at a ranch home in Tucson, Arizona.32 The defendant was considered incompetent to stand trial because of an inability to consult with his lawyer regarding his defense, and by failing to demonstrate a factual understanding of the proceedings of the murder trial.33 This verdict was determined in part by information collected by an Electroencephalography (EEG) and Computerized Tomography scan demonstrating temporal lobe damage as the cause for irrational behavior.

26. Id.
27. Arnaudo, supra note 2.
29. Id.
31. Aharoni et al., supra note 1; see also Commonwealth v. Pirela, 929 A.2d 629 (Pa. 2007).
32. Jones & Shen, supra note 6 (citing McMurtey v. Ryan, 539 F.3d 1112 (9th Cir. 2008)).
33. McMurtey v. Ryan, 539 F.3d 1112 (9th Cir. 2008).
And lastly, the defendant in *People v. Goldstein* attempted to produce evidence from a Positron Emission Tomography scan to support a claim of severe schizophrenia and lack of intent in pushing a woman into the course of a subway train in New York City. The court in this case allowed testimony from two forensic psychiatrists, one for defense counsel and one for the prosecution. Defense counsel’s expert testified the defendant was suffering from exacerbated schizophrenic symptoms, which did not allow him to process right from wrong. Whereas prosecution’s expert testimony stated defendant’s schizophrenia symptoms were mild and at the time of the crime his disease was in remission. The court ultimately found defense counsel’s theory of the case and the Positron Emission Tomography scan evidence unconvincing, and Goldstein was found guilty of murder. Precedent paints an inconsistent picture with regard to the assessment of neuroscientific evidence in the courtroom, and a few factors contribute to this divergence.

C. Determining Criminal Responsibilities

One of the challenges facing the use of neuroscience in the courtroom is the highly persuasive effect neuroimaging can have on uninformed juries. Introduction and examination of an image by an expert witness will likely bias a lay jury with the persuasive power of the images and expert testimony. Notably, there are discrepancies amongst experts on how neuroimages should be analyzed, and this subjectivity is the crux of medical analysis.

Some researchers argue that neuroimaging will never find a home in the courtroom, but hopeful proponents imagine neuroimaging will illuminate defendant culpability. Issues arise when responsibility is viewed not as a decision-making process in a quadrant of the brain, but as a social construct. If responsibility is a social construct that exists under the rules of society, and not in a lobe of the brain, a court cannot use neuroimaging to evaluate whether a person is more or less responsible in a constructed social system. Additionally, scholars have argued that the purpose of the law reaches outside the scope of fact finding, but is also intended to set societal

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36. *Id.*
37. *Id.*
38. *Id.*
norms, and neuroscience has no role in norm setting.\footnote{Vincent, supra note 12 (citing Stephen Morse, Neuroethics: Defining the Issues in Theory, Practice, and Policy, Moral and Legal Responsibility and the New Neuroscience 33 (Judy Illes ed. 2006)).} Furthermore, the law has already created avenues that excuse defendants of culpability when their ability to choose responsible behavior is impaired, i.e. the insanity defense.\footnote{Paul S. Appelbaum, Behavioral Genetics And The Punishment Of Crime, 56 L. PSYCHOL. 25 (2005).} But the looming question for the criminal justice system concerns the applicability of neuroimaging studies in determining criminal responsibility.\footnote{Id.}

\section*{D. Criminal Culpability}

To prove culpability prosecution must generally prove a defendant has committed an offense knowingly, recklessly, or with criminal negligence.\footnote{Model Penal Code § 2.02 (1962).} This element establishes the \textit{mens rea}, i.e., the mental state of the defendant while committing the crime. Namely the court needs to determine whether the defendant meets the element of intent present in a crime. The topic areas below elucidate the ability of current neuroscience to prove and disprove criminal intent factors.

\subsection*{1. Determining Deception}

One criminal responsibility factor neuroscience aims to solve is lie detection. Neuroscientists hope to detect when a defendant is lying using brain imaging to create a map of brain patterns that correspond to deceptive behavior. Although some companies have begun to make a profit by claiming they have mastered this ability, the general neurological community remains skeptical.\footnote{No LIE MRI, http://www.noliermi.com/ (last visited May 24, 2015).} The Guilt Knowledge Test was a study conducted by the University of Pennsylvania to map deception in the brain using functional Magnetic Resonance Imaging to monitor “regional blood flow.”\footnote{Daniel D. Langleben et al., Brain Activity During Simulated Deception: An Event-Related Functional Magnetic Resonance Study, 15 NEUROIMAGE 727 (2002).} The study claimed to have perceived a difference in blood oxygenation levels when a participant was truthful or deceptive.\footnote{Id.} Each of the 18 participants was asked a series of questions for which they had to answer yes or no.\footnote{Id.} The participants were all given a set of cards, each card signaled whether the participant should lie or be truthful.\footnote{Id.} Some of the
answers would be false and the questioner had no knowledge of the accuracy of the answers.\textsuperscript{50} The study noted a contrast in the Functional Magnetic Brain Imaging when a participant was lying or telling the truth.\textsuperscript{51} The study concluded there is a “neurophysiological difference” between lying and truth telling.\textsuperscript{52}

2. Impairment Through Malformation

Another criminal culpability factor neuroscience has pioneered is the influence of brain abnormalities over behavior. “[D]amage to certain sectors of prefrontal cortex produces a severe impairment of decision-making and disrupts social behavior.”\textsuperscript{53} A study conducted in the Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience from the University of Iowa College of Medicine determined that early damage to the prefrontal cortex of the human brain could impair development. The study showed an ability to demonstrate a lack of social responsibility through neuropsychological evidence, observation of subjects, and brain imaging. The study was uniquely telling because the hypothesis and conclusions aligned by determining that adults who have suffered lesions in the brain during adulthood have had decades of established social development that can balance prefrontal brain damage, but alternatively, subjects who suffered prefrontal damage early in their lives were not able to develop advanced behavioral understanding or appropriate application.\textsuperscript{54} Research has shown damage to the brain causes “abnormal development of social and moral behavior,” and this development appears to be “independent” of the subject’s influencing social factors, which did not seem to have authority over the affected subjects.\textsuperscript{55}

3. The Adolescent Mind

Lastly, and a subject area covered recently, includes the culpability of an adolescent criminal. The National Juvenile Justice Network has conducted a number of research studies verifying the inability of adolescents to fully comprehend and establish intent as an adult. The studies contend the adolescent brain undergoes an extensive development prior to adulthood including a “pruning” process in which the brain’s “gray

\textsuperscript{50} Id.
\textsuperscript{51} Daniel D. Langleben et al., \textit{Brain Activity During Simulated Deception: An Event-Related Functional Magnetic Resonance Study}, 15 \textit{NEUROIMAGE} 727 (2002).
\textsuperscript{52} Id. at 731.
\textsuperscript{53} Steven W. Anderson, \textit{Impairment Of Social And Moral Behavior Related To Early Damage In Human Prefrontal Cortex}, 2 \textit{NATURE NEUROSCIENCE} 1032 (1999).
\textsuperscript{54} Id.
\textsuperscript{55} Id. at 1036.
matter” depletes and the body eliminates idle neural synapses and strengthens those used more frequently, enhancing an adolescent’s ability to engage in “higher-thinking.” Most persuasive is the idea that juveniles exhibit altered behavior in moments of “hot or cold cognition.” The study showed, as adolescent brains are undergoing development their behavior is influenced by their emotions, and their emotions are highly influenced by their immediate environment. Although evidence collected by the National Juvenile Justice Network, and similar organizations, is not determinative, it is compelling, and has influenced decisions such as removing juveniles from the criminal punishment of death row. These monumental neuroscientific breakthroughs are the result of analysis and interpretation of neuroimages. These images are the key component in the presentation of neurological evidence.

D. Method of Image Creation

Neurologists implement a variety of imaging studies in order to make their diagnosis. The imaging information collected is juxtaposed with a physical assessment of the patient. These two methods of data collection allow the physician to assess their patients and make a diagnosis. There is a vast degree of subjectivity involved in data collection from technique of collection to data interpretation. There are four methods of neuroimaging generally used, including Magnetic Resonance Imaging, Computerized Tomography, Positive Emission Topography and Single Photon Emission Computerized Tomography scans. Each has strengths and weaknesses in identifying brain abnormalities.

Magnetic Resonance Imaging, commonly known as MRI, uses a “powerful magnet” to acquire structural images of the brain. The high spatial resolution of MRI has proven useful in discovering a variety of “physiological” brain abnormalities such as brain hemorrhages. Computerized Tomography (CT) can also be used for collecting structural imaging. CTs are recognized for their “high spatial and temporal resolution.” This means that the scan is capable of obtaining clear resolution through a greater number of pixels, in addition to rapid photon transmission. Jane Moriarty states, CT and MRI scans are typically presented in U.S courts as evidence of brain trauma or neurological disease;

57. Id.
58. Id.
59. Shafi, supra note 9, at 31.
60. Id.
61. Shafi, supra note 9.
62. Id. (citing Shelia Rankin, CT and MRI, 23 SURGERY 239 (2008)).
she argues that there “is general agreement and substantial proof of reliability that CT scans and MRI technology can detect brain injury, damage or atrophy.” 63 The Louisiana court of appeals accepted CT and MRI images of a plaintiff’s brain in McMahon v. Regional Transit Authority to prove major contusions of the plaintiff’s brain after being hit by a city bus.64 The CT and MRI scans were approved and accompanied by expert testimony explaining how the scans revealed significant bleeding in the brain after the accident.

A SPECT scan or Single Photon Emission Computerized Tomography serves a unique imaging purpose. Unlike an MRI or CT, a SPECT scan will create a neuro-profile by observing blood flow throughout the brain.65 An increase or decrease in blood flow could signify an abnormality. SPECT scans are generally used to diagnose “neurological disorders” such as dementia.66 The Michigan court of appeals allowed the use of a SPECT scan in Fini v. General Motors Corp., concluding the scans were relevant and reliable in demonstrating evidence of the plaintiff’s brain function idiosyncrasies after the defendant’s car collided with the plaintiff’s vehicle.67

Positive Emission Topography scans (PET) are an invasive imaging method which collects information regarding “blood flow, blood volume and metabolism” after injecting the patient with a radioactive element that presents itself in the image.68 The element is used as a trail of breadcrumbs to “map” the activity in the brain.69 The purpose of a PET scan is to “show cerebral dysfunction” that cannot be adequately portrayed by structural imaging such as a CT scan.70 The Supreme Court of Florida determined that a trial judge abused his discretion in a burglary and murder case by refusing to admit PET scan imaging to allow a neuropsychologist to further evaluate the defendant’s neurological damage.71

Lastly, Functional Magnetic Resonance Imaging, also known as fMRI, is the grander successor of PET and SPECT scans.72 The purpose of the

63. Shafi, supra note 9 (quoting Jane Moriarty, Flickering Admissibility: Neuroimaging Evidence In The U.S. Courts, 26 BEHAV. SCI. & L. 29, 40-1 (2008)).
65. Shafi, supra note 9.
66. Shafi, supra note 9, at 33.
68. Shafi, supra note 9, at 34.
70. Shafi, supra note 9 (quoting Zwany Metting et al., Structural And Functional Neuroimaging In Mild-To-Moderate Head Injury, 6 LANCET NEUROLOGY 699, 703 (2007)).
72. Shafi, supra note 9.
fMRI is to study neurochemistry by measuring "localized brain activity by determining blood flow and oxygen utilization in portions of the brain." A district court in North Dakota used fMRI images to monitor adolescents as they watched simulated video games to measure violence. The court ultimately ruled the information was inconclusive, but the images were allowed in the courtroom as evidence.

Legal professionals and neurologists are attempting to use each of these methods to provide a link between brain activity and neural patterns, but no evidence exists linking specific brain patterns to specific behavior. Current correlations are based on theory, but theory in conjunction with physical examination and expert testimony may be enough to pass the admissibility threshold. But the acceptance of neuroevidence implicates other concerns beyond admissibility, including the ethics of practice.

E. Neuroethics

Neurolaw has ethical implications, such as invading a person's most private and personal space, their mind; or procedural legal consequences, such as depriving a defendant of their Fifth Amendment right to remain silent, by taking the liberty of entering the defendant's mind. "Recently scholars of neurolaw have considered how functional neuroimaging affects the First Amendment right to privacy, the Fourth Amendment right against (mental) search and seizure, the Fifth Amendment right against self-incrimination, the possibility of introducing neuroimaging results as legal evidence, and the degree to which the legal system should adopt a more rehabilitative and less punitive approach to offenders." The last and most riveting challenge is analyzing neuroimaging to determine which defendants have diminished capacity, and which defendants have a lack of virtue, and "... until we find a satisfactory way to demarcate the bad from the mad, this conceptual difficulty will pose a significant stumbling block."

73. Shafi, supra note 9 (quoting Paul S. Appelbaum, The New Lie Detectors: Neuroscience, Deception, And The Courts, 58 PSYCHIATRIC SERVICES 460, 461 (2007)).
74. Entm't Software Ass'n v. Blagojevich, 404 F. Supp. 2d 1051 (N.D. Ill. 2005) aff'd, 469 F.3d 641 (7th Cir. 2006).
75. Id.
77. Vincent, supra note 12.
79. Vincent, supra note 12, at 18.
F. The Future of Neurolaw

On its current trajectory neuroscience will be the catalyst behind behavioral statutes. These statutes would aim to encompass the guidelines necessary to penalize human behavior based in part on brain imaging. Currently litigants use neuroimaging in civil litigation and criminal trials to affirm brain or spinal injuries, but researchers claim that neuroimaging can be used as a mechanism to “demonstrate the propensity for violence, the capacity to stand trial, as evidence of malingering, or to help establish or diminish the criminal responsibility of a defendant." Regardless of its intended use neuroimaging can likely be intimidating and confusing to a jury, and an expert witness would be necessary to alleviate the stress of interpretation. Brain imaging can be highly relevant and probative depending on the type of case, and it is physicians and lawyers who have the ability to develop a new field of medicolegal research, which can help each profession advance public policy.

G. Correlation Between DNA and Neurological Evidence

Public policy and law have already demonstrated a willingness to accept novel science. The willingness to admit scientific breakthroughs is displayed by the acceptance of DNA evidence. As alluded to earlier, the Federal Rules of Evidence have bestowed immense power on the word “admissible.” Admissibility is the crux to presenting a strong legal argument in trial. Every piece of evidence presented during trial must meet the admissibility standard set by the Federal Rules of Evidence. Public policy has played a role in what is deemed acceptable in the courtroom. In 1980 states began enacting laws that made the collection and presentation of DNA admissible evidence. The inauguration of DNA evidence was only the beginning of contested admissibility standards. Current DNA statutes focus on collection, method of gathering data, and qualifying admissibility. The following discussion aims to draw a corollary between DNA admissibility and the admissibility of neuroimaging evidence in the courtroom, with a special focus on Minnesota law. The following will outline: (a) what is required for neuroevidence to be deemed admissible by comparing DNA admissibility, and (b) how public policy should be fashioned to support its adoption.

Deoxyribonucleic acid (DNA) acts as the framework for the human
genome.\textsuperscript{83} DNA strands can be collected from human sources such as blood, teeth, and saliva.\textsuperscript{84} “Awareness” of the power of DNA to solve crimes has increased since the 1980s.\textsuperscript{85} In 1994 federal law authorized the Federal Bureau of Investigation to create and manage a national DNA database.\textsuperscript{86} The database would be a central information repository where “DNA profiles generated from samples collected from people under applicable legal authority and samples collected at crime scenes can be compared to generate leads in criminal investigations.”\textsuperscript{87}

“DNA sequences” from crime scenes are analyzed and compared to those in databases to help identify suspects.\textsuperscript{88} “State and federal DNA databases have proved instrumental in solving crimes, reducing the risk of convicting the wrong person, and establishing the innocence of those wrongly convicted.”\textsuperscript{89} Federal statutes give authority to collect DNA samples from federal offenders.\textsuperscript{90} The organization and collection of the DNA database is coordinated by state and federal jurisdiction. State law determines offender profiles susceptible to the state DNA database, while federal law determines which State profiles are transferred to the national DNA database.\textsuperscript{91}

“Minnesota law requires those convicted of a felony, those released from prison after serving a felony sentence, those felons whom the state accepts through an interstate compact, and those charged with certain predatory felonies to submit a DNA sample.”\textsuperscript{92} Juvenile and adult offenders charged with committing or attempting to commit a felony must submit to DNA collection upon sentencing.\textsuperscript{93} The Bureau of Criminal Apprehension collects and maintains DNA samples to create into profiles.\textsuperscript{94} A suspect’s DNA sample will be destroyed if the suspect is found innocent.\textsuperscript{95}

Federal and State law statutes iterate the lawful procurement of felony

\textsuperscript{83} NATHAN JAMES, CONGRESSIONAL RESEARCH COMMITTEE, DNA TESTING IN CRIMINAL JUSTICE: BACKGROUND, CURRENT LAWS, GRANTS, AND ISSUES (2012).
\textsuperscript{84} Id.
\textsuperscript{85} Id. at 2.
\textsuperscript{86} NATHAN JAMES, CONGRESSIONAL RESEARCH COMMITTEE, DNA TESTING IN CRIMINAL JUSTICE: BACKGROUND, CURRENT LAWS, GRANTS, AND ISSUES (2012).
\textsuperscript{87} Id. at 2.
\textsuperscript{88} Id. at 1.
\textsuperscript{89} Id.
\textsuperscript{90} NATHAN JAMES, CONGRESSIONAL RESEARCH COMMITTEE, DNA TESTING IN CRIMINAL JUSTICE: BACKGROUND, CURRENT LAWS, GRANTS, AND ISSUES (2012).
\textsuperscript{91} Id.
\textsuperscript{92} JEFFREY DIEBEL, HOUSE RESEARCH DEPARTMENT, MINNESOTA’S CRIMINAL DNA COLLECTION AND PRESERVATION LAWS 1 (2006).
\textsuperscript{93} Minn. Stat. § 609.117, subd. 1(1), (2) (1989).
\textsuperscript{94} Minn. Stat. § 609.117, subd. 1 (1989).
\textsuperscript{95} JEFFREY DIEBEL, HOUSE RESEARCH DEPARTMENT, MINNESOTA’S CRIMINAL DNA COLLECTION AND PRESERVATION LAWS (2006).
DNA sampling. The purpose of DNA collection is to create a databank large enough to convict reoffending criminals. This purpose was facilitated by the role DNA evidence played in criminal prosecution.

**H. DNA Admissibility**

The advantage of DNA evidence is that it can determine with “virtual certainty” the presence of a criminal at the crime scene. Forensic scientists use statistical analysis to determine the source of a DNA sample and match it to a DNA profile; thus, a determination is made by interpreting the quantitative information produced by the DNA test. The statistical significance of a match is calculated by implementing a two-step process: (a) a determination as to the probability of the collected DNA being found in a random sample population, and (b) a determination as to the probability of having the same DNA structure in the collection and database. To be admissible the information must be valid and reliable. To measure validity and reliability the court analyzes the technique used to collect the data. "A technique is valid if it produces accurate results [. . . ] A technique is reliable if it produces the same results time and again." The Frye court determined expert testimony to be admissible based on scientific principles and procedures after they have “gained general acceptance.” Application of the Frye verdict to the acceptability and admissibility of DNA evidence supports two elements of DNA evidence: (a) DNA evidence has the acceptance and backing of the scientific community to produce reliable information, and (b) general acceptance of certain scientific techniques that produce reliable results. Thus, the goal of neurological evidence is to establish general acceptance through: (a) standardization of neurological evidence collection, to convict criminals, and (b) general acceptance in the scientific community of collection techniques.

**1. Neurological Admissibility.**

The debate surrounding the merits of neuroimaging in the courtroom is contentious. Proponents argue neuroimaging evidence may be more

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97. Id.
98. Id.
99. Id.
100. Id. at 2477.
102. Smith & Gordon, supra note 96.
scientifically reliable than other forms of forensic evidence. Ultimately two points befuddle scholars and postpone implementation in the courtroom, uniformity in neuroimaging analysis and collection.

I. Future Standardization of Neurolaw

Critics of neuroimaging evidence question the reliability of neuroscience, and comment on weaknesses like the imperfect spatial resolution provided by the images. “Critics argue courtroom use is premature because the scans necessarily involve expert interpretations, which depend heavily on the methods employed by the individual scientists and researchers conducting the scans.”

Data is interpreted under the implementation of varying choices and considerations. The lack of standardization in data analysis causes great distress to the legal community. The interconnected nature of the brain makes connecting brain activity to behavior complex. Ultimately, legal scholars are concerned neuroimaging provides little probative value for the jury, but instead confuses and dazzles the jury with potentially prejudicial evidence.

Ironically, a study conducted by the Institute of Cognitive Neuroscience revealed DNA “mixture interpretation” to be subjective. When 17 North American DNA examiners were asked to submit their interpretation of an identical DNA sample the results were inconsistent. Other studies have evaluated the amount of subjectivity involved in interpreting DNA tests and the amount of laboratory error present. Needless to say, interpretation techniques and general acceptance of DNA evidence is questionable, and as neurolaw emerges and continues to be rejected DNA scrutiny is amplified.

Proponents of neuroimaging claim that reluctance may stem from the legal fields’ commitment to supporting current paradigms. Even though there is a certain amount of unpredictability in neuroimaging analysis, analysis is defined by probability and inference interpretation; this is standard scientific practice. Thus, critics may not be resisting a new area

104. Id.
105. Id. at 386.
106. Teitcher, supra note 103.
107. Id.
108. Itiel E. Dror & Greg Hampikian, Subjectivity And Bias In Forensic DNA Mixture Interpretation, 51 SCI. JUST. 204 (2011).
109. Id.
111. Teitcher, supra note 106.
due to a lack of predictability, but because there is discomfort with scientific practice. This inadvertently leads to a double standard, with preference for DNA evidence, for example. If neuroscience will be used to assess criminal responsibility it is imperative two mechanisms are understood: (a) how experts will commonly analyze a neuroimage, and (b) what criminal responsibility means in the context of image interpretation. Additionally, legal guardians are potentially denying a defendant’s rights to effectively and truthfully present their cases, since defendants are more likely to use neuroimaging evidence.\textsuperscript{112} Neuroimaging would “provide litigants with the tools necessary to fully present and effectively argue their case and would allow juries to evaluate and consider useful functional neuroimaging evidence during the course of a trial.”\textsuperscript{113} The debate amongst scholars and legal guardians is rich regarding neuroscience in the courtroom. Currently, there is no right or wrong answer, but the debates follow themes; in particular, standardization and reliability. These concerns raise the question, whether law can be crafted to accommodate neuroscientific evidence the way it has DNA evidence?

\textit{1. Statute Construction.}

State interpretation of the federal DNA directive is well constructed to include when and how DNA evidence is admitted in criminal prosecution. For instance Minnesota houses two guiding statutes in its “Evidence; Witness” and “Criminal Code” chapters. Minnesota DNA statutes do not require expert testimony to accompany DNA evidence because DNA interpretation as a generally accepted scientific technique has already been recognized. Minnesota Statute §634.25, Admissibility of Results of DNA Analysis, states:

In a civil or criminal trial or hearing, the results of DNA analysis, as defined in section 299C.155, are admissible in evidence without antecedent expert testimony that DNA analysis provides a trustworthy and reliable method of identifying characteristics in an individual’s genetic material upon a showing that the offered testimony meets the standards for admissibility set forth in the Rules of Evidence.\textsuperscript{114}

Additionally, Minnesota requires the DNA analysis of certain offenders setting the stage for instances in which DNA interpretation is relevant and mandatory, employing consistency in application.\textsuperscript{115}

\begin{itemize}
  \item \textsuperscript{112} \textit{Id.}
  \item \textsuperscript{113} \textit{Id.} at 358.
  \item \textsuperscript{114} Minn. Stat. § 634.25 (1989).
  \item \textsuperscript{115} Minn. Stat. § 609.117 (2010).
\end{itemize}
Similarly, a statute outlining the admissibility of neuroimaging as trial evidence should include references to the science’s trustworthiness and reliability. A neuroimaging statute will diverge from its DNA predecessor by requiring expert testimony to be introduced at trial. Like DNA evidence neuroimages can be complicated to interpret. But unlike DNA evidence, the subjectivity associated with recognizing neuroimaging evidence is highly publicized and a source of contention.

To eliminate the blind acceptance of neurodiagnosis the statute will require expert testimony clearly delineating the physician’s diagnostic map. Of course this requirement will present some challenges, such as whether or not the physician who ran the original test and concluded with the presented diagnosis must be the one to testify, or would perhaps a neuropsychologist be adequate replacement? A statute of the magnitude suggested would look something like this: In a civil or criminal trial or hearing the power of the court may admit neuroimaging or neurological evidence to support a claim as long as the evidence meets the standard for admissibility set forth in the Rules of Evidence, and the accompanying expert testimony assures the trier of fact of the evidences’ trustworthiness and reliability.

A statute addressing the needs of the legal community would place validity in the analysis of neuroimages by radiologists and neurologists in the courtroom, and allow the legal court system to do the rest, balance the evidence. Statute implementation would better allow judges to facilitate juror interpretation, by giving them the power to ask the appropriate questions and insure presentation meets the Federal Rules of Evidence standards. Science is ever expanding, as is the terrain of the law. A bridging of Law and Science early in their communion would prevent back tracking.

Furthermore, the Federal Rules of Evidence lend themselves not only to steadfast rules, but also instructive commentary. If the legal field allows neuroimaging to enter as trial evidence it should provide practitioners with instructions on implementation. Articulation of neuroimaging in the courtroom ought to be entered as a comment to “Testimony by Experts” in the Federal Rules of Evidence.116 The comment should communicate confidence in the methods used by physicians to analyze and assess neuroimaging evidence, as well as a commitment to the authority of the people to protect the rights of its citizenry through powers such as the jury system.

CONCLUSION

A fair amount has been written about the admissibility of neuroimaging

evidence in the courtroom, but no known work has been presented examining how neuroevidence and forensic individualization compare.\textsuperscript{117} The goal of this paper was to research the current state of neuroimaging and analysis as it relates to the law, as well as to explore a comparative study of neuroevidence and DNA evidence. The neuroscience field has the tools available to help determine a propensity for violence as well as diagnose mental disclosure. Once standards have been set there is nothing limiting the facilitative power of neuroimaging in the courtroom. Although the acceptance of the field will create new problems, such as whether a mental disease can eliminate criminal culpability, the promise of new puzzles should not limit the potential power available. Research on the topic of neurolaw is on the cusp of new policy and procedural law. Further investigation and application will allow academics to develop more definitive conclusions and make legal applicability a reality. This paper aimed to illuminate an expansive issue, and analysis in this field of study is only just beginning.

\textsuperscript{117} Teitcher, \textit{supra} note 106.