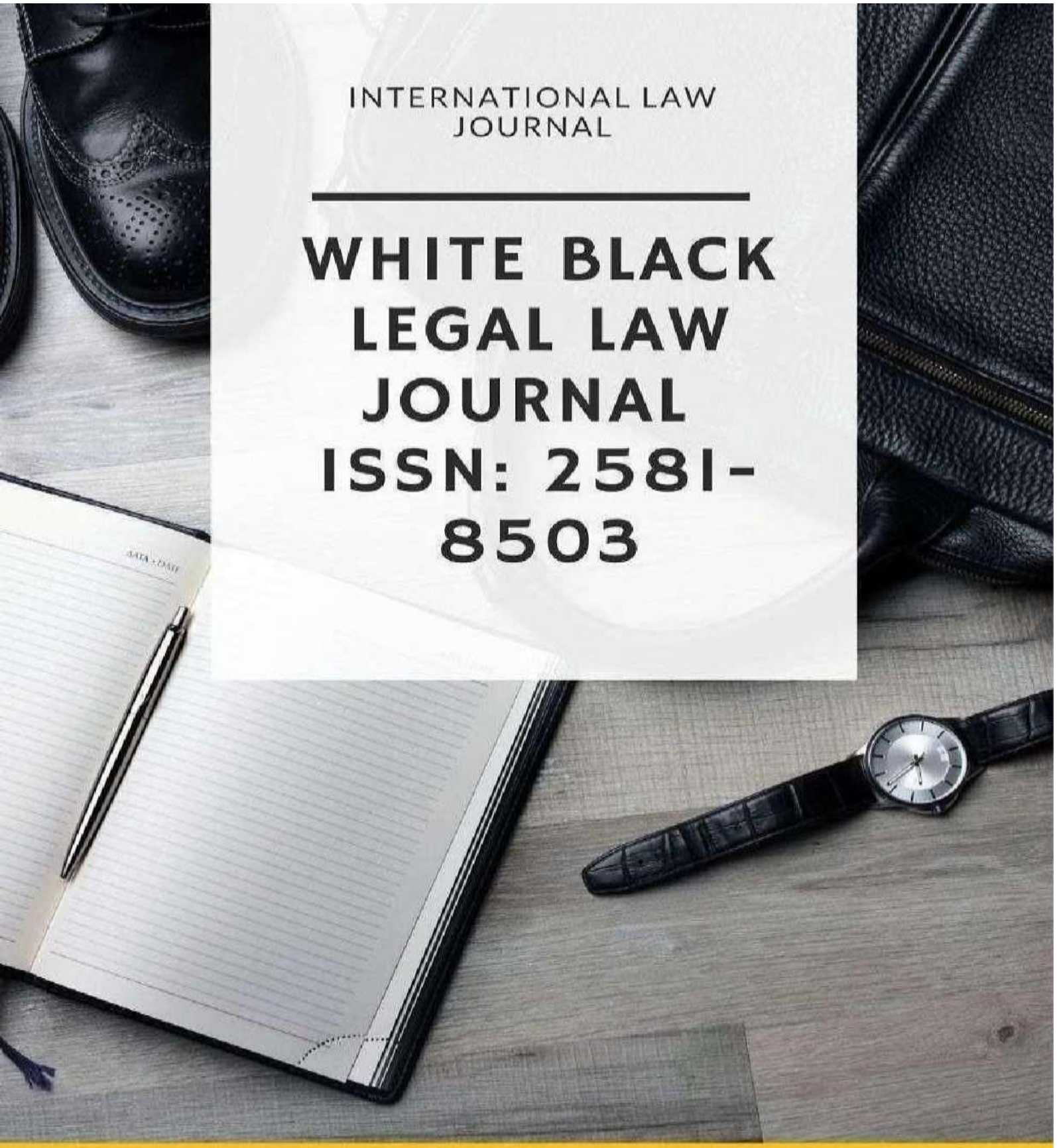

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A CROSS-JURISDICTIONAL STUDY ON THE ADMISSIBILITY AND RELIABILITY OF NEUROSCIENTIFIC EVIDENCE IN CRIMINAL JUSTICE SYSTEMS

AUTHORED BY - A R VARAVARNINI & Dr Ekta Gupta

Abstract

There has been a growing significance of neuroscientific findings within the framework of criminal law, particularly in light of cases involving issues of competency, insanity, diminished responsibility, mitigation at sentencing, and lie detection. The use of tools of neuroimaging such as fMRI, PET, EEG, neuropsychological assessment, and behavioral genetics is resulting in novel ways of looking into cognitive and behavioral matters. But it raises a lot of questions regarding its accuracy and constitutional implications in the courtrooms.

This paper will compare and analyze the admissibility of neuroscientific evidence in US, UK, India, and selected European jurisdictions. This study will focus on the different judicial procedures followed by each jurisdiction. The study will compare the Frye and Daubert test used in the US, methodological criticism in the UK, expert evidence as per Section 45 of the Indian Evidence Act and Bharatiya Sakshya Adhiniyam in India, and mitigation approaches in Europe. Some important landmark judgments include US v. Semrau, R v. Reed & Reed, and Selvi v. State of Karnataka.

In conclusion, the research reveals that the use of scientific knowledge in neuroscience is more convincing in cases where it serves as mitigating or explanatory evidence rather than evidence of culpability or intention. The study asserts that there is a need for courts to adopt rigorous standards for reliability, clear thinking, and constitutional protections.

Keywords: Neuroscience, Criminal Law, Evidence, Admissibility, Neurolaw.

1. Introduction

One of the most critical innovations in recent times within evidentiary jurisprudence is the emergence of neuroscientific studies in criminal law. With the advancement of neuroscience, there is now a new dimension to evidentiary issues where courts have had to deal with experts offering evidence through brain scanning technologies such as functional magnetic resonance

imaging (fMRI), positron emission tomography (PET), electroencephalography (EEG), neuropsychology, among others. These tests aim to establish the presence of cognitive deficiencies, impulsive behaviors, deceit, and poor decision-making skills[1].

There have been several instances where neuroscientific tests have been employed in criminal trials. In particular, the use of brain scans has been more pronounced in insanity defense cases, diminished responsibility claims, competency hearings, juvenile criminal cases, and capital punishment mitigation. The neuropsychological tests may be used to show cognitive weaknesses, impaired executive functions, intellectual disabilities, and vulnerability to coercion This is another example of how there is a trend toward the incorporation of scientific principles into legal reasoning[2].

From a philosophical perspective, the discipline of neuroscience has helped formulate a shift from the reliance on moral reasoning to describe criminal acts to a more scientific, mechanistic approach. Criminal law is based on the presumption of free will and voluntary action, as well as the notion that humans are morally responsible for their actions. While these biological perspectives may assist judges in comprehending human behavior, they pose problems to the moral foundation of criminal culpability[3].

Neuroscience offers an interesting avenue for law but poses several legal issues. The judicial system has to maintain a fine balance between novel scientific discovery and evidentiary reliability all the time. One of the most critical legal challenges is establishing whether the presented information proves the presence of certain facts necessary for the determination of guilt. Therefore, it is sometimes challenging for the judges to distinguish when the evidence helps determine facts, and when it is pure conjecture cloaked in scientific terms[4].

The possibility of overreliance on evidence that seems visually clear and precise should also be noted. This phenomenon, sometimes described as “neuro-realism” or “neuro-authority bias,” may distort rational adjudication by giving undue weight to expert testimony. This problem is complicated by the lack of a uniform standard for admitting such evidence worldwide. While some systems use stringent gatekeeping criteria related to the scientific validity of the findings, others leave this decision-making process to the judicial discretion or

[1] Teneille R Brown and Emily Murphy, ‘Through A Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant’s Past Mental States’ (2010) 62 *Stanford Law Review* 1119.
[2] Judy Illes and Eric Racine, ‘Imaging or Imagining? A Neuroethics Challenge Informed by Genetics’ (2005) 5 *American Journal of Bioethics* 5; Daniel D Langleben and Jane Campbell Moriarty, ‘Using Brain Imaging for Lie Detection: Where Science, Law and Research Policy Collide’ (2013) 63 *Psychology, Public Policy, and Law* 1.
[3] Joshua Greene and Jonathan Cohen, ‘For the Law, Neuroscience Changes Nothing and Everything’ (2004) 359 *Philosophical Transactions of the Royal Society B* 1775.
[4] Owen D Jones, Jeffrey D Schall and Francis X Shen (eds), *Law and Neuroscience* (Aspen Publishers 2014).

general provisions regulating expert evidence[5].

The following are the primary research questions that will be answered in this thesis. Can neuroscience conclusively establish criminal intent, fraud, or diminished responsibility? How have different legal frameworks gone about assessing the admissibility of neuroscience evidence? What kind of legal changes need to be made to enable the legitimate application of science in supporting justice?

In this study, the comparative approach to doctrinal analysis will be employed. It further undertakes case law analysis of leading decisions involving neuroscientific claims in criminal proceedings. \ In this regard, the paper aims at exploring how criminal justice systems should interact with neuroscientists without compromising on their evidence and procedural standards.

2. Understanding Neuroscientific Evidence

2.1 Meaning and Scope

Neuroscientific evidence is defined as expert testimony based on scientific knowledge about the brain, nervous systems, cognitive processes, and their connection with human behavior. In the courtroom, it typically takes the form of either medical images, psychological testing, electrophysiology, or genetical analysis that might shed light on the mental functioning of a suspect in terms of decision making, impulse control, memory, and neurological problems.[1] Neuroscientific evidence is presented by experts like neurologists, psychiatrists, psychologists, radiologists, and neuroscientists[6].

The increased importance of neuroscientific evidence in criminal law is connected with its ability to assist in the determination of the presence of necessary mental capacity in the accused person. Neuroscience helps to explore the possibility of any brain abnormality that may affect human behavior. Nevertheless, neuroscience cannot solve legal problems but simply explains certain circumstances[7].

2.2 Types Most Commonly Used in Criminal Courts

The first important tool in this field is functional magnetic resonance imaging (FMRI). The term ‘functional activity mapping’ has been attributed to FMRI because this test helps to detect which regions of the brain show more activity under specific conditions. Though the use of

[5] Deena Skolnick Weisberg, Frank C Keil, Joshua Goodstein, Elizabeth Rawson and Jeremy R Gray, ‘The Seductive Allure of Neuroscience Explanations’ (2008) 20 *Journal of Cognitive Neuroscience* 470.
[6] Owen D Jones, Jeffrey D Schall and Francis X Shen (eds), *Law and Neuroscience* (Aspen Publishers 2014).
[7] Stephen J Morse, ‘Brain Overclaim Syndrome and Criminal Responsibility: A Diagnostic Note’ (2006) 3 *Ohio State Journal of Criminal Law* 397.

FMRI has received much interest in criminal cases, there are debates on how the results can be interpreted[8].

The second widely applied method is positron emission tomography (PET) scan. It has been used in criminal proceedings to detect any difficulties linked with head injury, dementia, schizophrenia, among others. The courts have at times admitted PET scans while considering mitigating factors or competency[9].

Electroencephalogram (EEG) refers to the measurement of the electrical activities of the brain through placing electrodes on the scalpFor forensic purposes, modified versions of EEG have been employed for techniques like event-related potentials and "brain fingerprinting." However, the Indian legal system has allegedly used BEOS profiling to identify experience-based knowledge, although the scientific basis of this approach has always remained controversial[10].

The term Neuropsychological Testing refers to standardized testing procedures used to measure cognitive skills such as memory, executive functioning, attention, language, and reasoning. Neuropsychological testing has frequently been used in criminal proceedings to prove that an individual is mentally retarded or suffering from dementia or brain injury, among other psychological impairments that relate to competency, insanity, or mitigation. While imaging tests provide pictures of the brain, neuropsychological testing measures cognitive skills[11].

Behavioral genetics is another evolving subfield of neuroscience in which the role of the Monoamine Oxidase A (MAOA) gene has gained attention in many scientific studies. Defense attorneys in some legal jurisdictions have attempted to present behavioral genetics evidence in some cases, despite court concerns about genetic determinism[12].

2.3 Uses in Criminal Law

Neuroscientific evidence can also find application in certain aspects of criminal procedure. For example, neuroscientific evidence can help determine an individual's competency to participate in a trial process since the issue may arise as to whether the defendant is capable of

[8] Teneille R Brown and Emily Murphy, 'Through A Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant's Past Mental States' (2010) 62 *Stanford Law Review* 1119.
[9] Deborah W Denno, 'Crime and Consciousness: Science and Involuntary Acts' (2002) 87 *Minnesota Law Review* 269.
[10] Henry T Greely and Judy Illes (eds), *Oxford Handbook of Neuroethics* (OUP 2011); Susan Raby and others, 'Brain Electrical Oscillation Signature Profiling in India: Scientific and Legal Issues'
[11] Antonio E Puente and others, *Neuropsychological Assessment of Neuropsychiatric and Neuromedical Disorders* (3rd edn, OUP 2008).
[12] Avshalom Caspi and others, 'Role of Genotype in the Cycle of Violence in Maltreated Children' (2002) 297 *Science* 851.

understanding the proceedings and providing instructions to their lawyer[13].

Second, it is often invoked in insanity or diminished responsibility claims. Thirdly, neuroscience has been employed in mitigation of sentencing. In sentencing offenders, judges may consider factors relating to youth brain immaturity, brain impairment resulting from physical injuries, drug addiction, or mental retardation[14].

Fourthly, a number of researchers have applied neuroscience to dangerousness prediction in an attempt to estimate recidivism risk on the basis of neurobiological and behavioral indicators.

Fifth, there have been attempts to use neuroscience for lie detection claims, particularly fMRI-based deception detection. They claim that they can detect brain reactions related to lies, but their legal acceptance remains limited[15].

3. Admissibility Standards Across Jurisdictions

There is a wide variation among jurisdictions when it comes to the reception of neuroscientific evidence in courts. The significance of the issue in question can be best observed in cases related to the criminal justice system, where the results of research conducted by neuroscientists could have an impact on the decision-making regarding the guilt of the person concerned, the extent of his liability, sentencing, and mental competency.

3.1 United States of America

Being among the leading states when it comes to the evaluation of the scientific proof by the court of law, The criteria, called the Frye test[16], who defined the rule of admission as the "general acceptance of the theory" within the scientific community.

Today's approach came from Daubert v. Merrell Dow Pharmaceuticals[17], Inc., in which the U.S. Supreme Court ruled that the Federal Rule of Evidence 702 replaced the Frye standard and made the judge responsible for being a gatekeeper.[2] In the Daubert ruling, the court must determine whether the expert testimony provided by the plaintiff is relevant and reliable. This framework was later reinforced in General Electric Co. v. Joiner and Kumho Tire Co. v. Carmichael[18].

[13] Richard J Bonnie, 'The Competence of Criminal Defendants: Beyond Dusky and Drope' (1992) 47 *University of Miami Law Review* 539.
[14] Roper v. Simmons 543 US 551; Miller v. Alabama 567 US 460.
[15] Daniel D Langleben and Jane Campbell Moriarty, 'Using Brain Imaging for Lie Detection: Where Science, Law and Research Policy Collide' (2013) 63 *Psychology, Public Policy, and Law* 1.
[16] Frye v. United States.
[17] Daubert v. Merrell Dow Pharmaceuticals, Inc..
[18] General Electric Co. v. Joiner; Kumho Tire Co. v. Carmichael.

The Daubert model has had direct consequences for neuroscientific evidence. One prominent case is the United States v. Semrau[19], where the defendant attempted to use fMRI lie detection as testimony. The judge rejected the testimony, as there was not enough scientific validation of its reliability, a lack of standardization procedures, ambiguity regarding practical validity, and uncertainties about error rates. This case is often cited as an example of judicial hesitation in admitting brain science deception evidence without proper scientific validation.

However, United States courts are more receptive to the use of neuroscience in sentencing than in establishing guilt. Brain injury, developmental immaturity, trauma, and intellectual disability have often been considered mitigating factors. Thus, the American position distinguishes between explanatory mitigation and conclusive proof of guilt[20].

3.2 United Kingdom

On the other hand, the United Kingdom follows a more conservative common law method that emphasizes the probity and openness of expert witness testimony. While there is no clear Daubert test in UK laws, the increasing trend in the UK courts is to examine expert methodology especially when the claim is scientific and has the potential to mislead a jury[21].

A major authority is R v T, concerning footwear mark evidence presented using probabilistic language. The Court of Appeal was critical of unsubstantiated claims based on statistics and emphasized the importance of explaining the underlying facts and methodology used by an expert in arriving at his/her conclusion[22].

In R v Reed and Reed, the court was concerned with the question of the admission of low-template DNA evidence and concluded that low-template DNA evidence can be admitted only within the confines of the science behind it[23].

This is of extreme significance in relation to neuroscientific evidence because, if this sort of evidence were admitted in a court of law, judges would most likely insist on the explanation of its methodology, margin of error, and applicability to the particular individual in question. British courts are particularly resistant to expert overstatement. Accordingly, neuroscience in the UK is more likely to be admitted cautiously as contextual evidence rather than deterministic

[19] United States v. Semrau.
[20] Teneille R Brown and Emily Murphy, 'Through A Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant's Past Mental States' (2010) 62 *Stanford Law Review* 1119.
[21] Law Commission, *Expert Evidence in Criminal Proceedings in England and Wales* (Law Com No 325, 2011).
[22] R v T.
[23] R v Reed and Reed.

proof of culpability[24].

3.3 India

In India, expert evidence is mostly governed by Section 45 of the Indian Evidence Act of 1872, which is now largely embodied in the Bharatiya Sakshya Adhiniyam of 2023. Under this section, experts can offer their opinion regarding science, foreign law, identification, handwriting, fingerprints, and other issues.[25]

This becomes significant in relation to forensic neuroscience. India has witnessed controversial use of narco-analysis, polygraph testing, brain mapping, and BEOS (Brain Electrical Oscillation Signature Profiling). These techniques were sometimes used during criminal investigations to claim discovery of concealed knowledge or experiential memory[26].

The use of narco-analysis, polygraphs, and brain electrical activity potential (BEAP) analysis has been challenged on the basis that they constitute unconstitutional violations of individual rights against self-incrimination and personal freedom, as declared by the Supreme Court in Selvi v. State of Karnataka[27].

The broader concern in India is that admissibility discussions have at times preceded scientific consensus. This makes judicial training and clearer statutory standards especially important[28].

3.4 Italy / Europe

Continental European jurisdictions, particularly Italy, have sometimes shown greater openness to neuroscientific material in mitigation and sentencing contexts. The focus may be less adversarial than Anglo-American evidentiary contests[29].

Italy attracted international attention through the Albertani decision, where evidence concerning the defendant's neurological abnormalities and low-activity MAOA genotype reportedly contributed to sentence reduction[30].

Across Europe more broadly, neuroscience has been discussed in relation to juvenile justice,

[24] Ian Freckelton, 'Criminal Trials and Neuroscience: The Forensic Context' (2016) 24 *Journal of Law and Medicine* 563.
[25] Indian Evidence Act, 1872; Bharatiya Sakshya Adhiniyam, 2023.
[26] Nita A Farahany, 'Incriminating Thoughts' (2012) 64 *Stanford Law Review* 351.
[27] Selvi v. State of Karnataka.
[28] K Vijayaraghavan, 'Brain Fingerprinting and the Indian Legal System' (2011) 53 *Journal of the Indian Law Institute* 245.
[29] A Meynen, 'Neurolaw and Criminal Justice in Europe' (2014) 22 *European Journal of Crime, Criminal Law and Criminal Justice* 1.
[30] Deborah W Denno, 'Courts' Increasing Consideration of Behavioral Genetics Evidence in Criminal Cases: Results of a Longitudinal Study' (2011) 61 *Michigan State Law Review* 967.

rehabilitation, risk assessment, and psychiatric detention. Yet even where admissibility is broader, most courts do not treat neuroscience as determinative proof of criminal conduct. Rather, it forms part of the assessment of responsibility and proportionality in sentencing[31].

It is important to understand that all of this indicates the importance of judicial control of neuroscientific evidence, even when it is scientifically sophisticated.

4. Reliability Challenges and Evidentiary Risks

The increasing use of neuroscientific evidence in criminal proceedings has generated significant enthusiasm, but also substantial concern regarding reliability. Courts are tasked with determining legal responsibility, not merely scientific possibility. The main threats to reliability in using scientific evidence come from incorrect interpretation of correlations, improper use of population studies in criminal proceedings, unproven methods of lie detection, unwarranted trust in expert witnesses, and the impact of visual imagery of the brain on judges and jurors.

4.1 Correlation is Not Causation

One of the most persistent errors in the courtroom use of neuroscience is the assumption that observed brain activity directly proves criminal intent or diminished responsibility. Most neuroscientific studies identify correlations between neural patterns and behaviour. A correlation may exist indicating the connection between particular brain areas and aggression, impulse control, fear, or deception activities, although it cannot be said that the neural patterns were responsible for motivating the accused into committing the crime[32].

The principle of criminal responsibility is grounded on notions like intentionality, knowledge, recklessness, voluntariness, and foresight. Those are legal terms which have been created through normative judgments rather than biological facts. Individuals with common neurological characteristics can also exhibit lawful conduct, while individuals with no neurological problem may commit serious offenses[33].

Thus, the court must not employ neuroscientific information as an alternative to legal thinking. Although neurological findings can provide assistance for psychiatric and behavioral analyses, it is unlikely that neuroscientific evidence would serve as a direct proof of the requisite mens

[31] Nita A Farahany (ed), *The Impact of Behavioral Sciences on Criminal Law* (OUP 2009).
[32] Stephen J Morse, 'Brain Overclaim Syndrome and Criminal Responsibility: A Diagnostic Note' (2006) 3 *Ohio State Journal of Criminal Law* 397.
[33] Stephen J Morse, 'Avoiding Irrational NeuroLaw Exuberance: A Plea for Neuromodesty' (2006) 62 *Mercer Law Review* 837.

rea[34].

4.2 Individual vs Group Data

A second challenge lies in translating scientific findings derived from group studies to individual defendants. Much neuroscientific research relies on averages drawn from sample populations. Such findings may be statistically useful in science, but they do not necessarily permit reliable conclusions about a specific accused person standing trial[35].

This creates what scholars describe as the "group-to-individual inference problem." A study may indicate that persons with a certain brain abnormality are more likely to display impulsivity, yet it cannot determine with certainty that one defendant acted impulsively during the offence. Likewise, risk markers for recidivism or aggression may predict probabilities across populations but remain weak tools for judging an individual's future conduct[36].

Criminal adjudication, however, requires individualised justice. Courts decide the responsibility of one person for one act under one set of circumstances. Scientific averages therefore have limited probative value unless carefully connected to the defendant through clinical evidence, history, and context[37].

4.3 Lie Detection Problems

Neuroscientific lie detection, especially fMRI-based deception testing, illustrates the gap between laboratory promise and courtroom reliability. Yet the evidentiary usefulness of these findings remains deeply contested[38].

First, false positives are a serious concern. Anxiety, confusion, memory failure, stress, or misunderstanding may produce neural responses misinterpreted as deception. Truthful individuals may therefore be labelled deceptive.

Second, many studies occur under laboratory limitations. Participants are usually healthy volunteers instructed to lie about trivial matters in controlled settings.

Third, countermeasures may undermine results. Subjects can intentionally alter attention, movement, mental arithmetic, or emotional focus to disrupt measured responses.

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[34] Owen D Jones, Jeffrey D Schall and Francis X Shen (eds), *Law and Neuroscience* (Aspen Publishers 2014).
[35] Martha J Farah, 'Neuroethics: The Practical and the Philosophical' (2005) 6 *Trends in Cognitive Sciences* 34.
[36] David L Faigman, David H Kaye, Michael J Saks and Joseph Sanders, *Modern Scientific Evidence: The Law and Science of Expert Testimony* (West, updated edn).
[37] Frederick Schauer and Barbara A Spellman, 'Is Expert Evidence Really Different?' (2013) 89 *Notre Dame Law Review* 1.
[38] Daniel D Langleben and Jane Campbell Moriarty, 'Using Brain Imaging for Lie Detection: Where Science, Law and Research Policy Collide' (2013) 63 *Psychology, Public Policy, and Law* 1.

Fourth, real investigations involve complexity absent in experiments. Statements may be partly true, partly false, mistaken, evasive, or based on poor memory. Binary truth-versus-lie models oversimplify actual testimony[39].

For these reasons, courts such as in United States v Semrau have declined to accept fMRI lie detection as sufficiently reliable[40].

4.4 Neuro-Authority Bias

Another evidentiary risk is the tendency of judges, jurors, and even lawyers to assign excessive weight to neuroscientific testimony merely because it appears technical and objective. This may be called neuro-authority bias. Experts using specialised terminology, statistical language, and imaging technologies may appear more credible than traditional witnesses, even where the underlying science is uncertain[41].

The danger is not limited to lay jurors. Judges may also struggle to evaluate competing scientific claims where they lack technical training. The aura of expertise can thereby obscure genuine methodological weakness[42].

Neuro-authority bias is particularly problematic when neuroscience is framed as revealing what a defendant "really intended" or whether the person "could not control" conduct. Courts must therefore treat neuroscience as expert opinion subject to challenge, not as infallible truth[43].

4.5 The "Seductive Allure" Problem

Closely related is the phenomenon known as the "seductive allure" of neuroscience explanations. Empirical studies have shown that people tend to rate explanations as more convincing when accompanied by neuroscientific language or images, even when the added material contributes little substantive value[44].

Brain scans are especially powerful visual evidence. Colourful images of highlighted brain regions may create an impression of precision and certainty. They are not photographs of thoughts or guilt[45].

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[39] Henry T Greely and Judy Illes (eds), *Oxford Handbook of Neuroethics* (OUP 2011).
[40] United States v. Semrau.
[41] Nita A Farahany, 'Neuroscience and Behavioral Genetics in US Criminal Law: An Empirical Analysis' (2016) 2 *Journal of Law and the Biosciences* 485.
[42] Law Commission, *Expert Evidence in Criminal Proceedings in England and Wales* (Law Com No 325, 2011).
[43] Teneille R Brown and Emily Murphy, 'Through A Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant's Past Mental States' (2010) 62 *Stanford Law Review* 1119.
[44] Deena Skolnick Weisberg, Frank C Keil, Joshua Goodstein, Elizabeth Rawson and Jeremy R Gray, 'The Seductive Allure of Neuroscience Explanations' (2008) 20 *Journal of Cognitive Neuroscience* 470.
[45] Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (Princeton University Press 2004).

In courtrooms, this creates a serious risk that visual presentation overwhelms legal reasoning. A jury may be more persuaded by an image than by nuanced testimony explaining its limits. Consequently, some scholars argue that judges should require cautionary instructions, restrict overstated graphics, and insist on clear explanation of uncertainty before admitting such material[46].

5. Comparative Case Studies

However, comparative case law shows that courts around the world are not rejecting neuroscientific evidence but instead find it challenging to establish under what conditions neuroscientific evidence can be believed. Some courts have shown restraint in their consideration of such evidence, particularly when used to demonstrate guilt or deceit. Below are some examples of cases where courts considered this issue.

Case 1 - United States v. Semrau (United States)

Facts: Dr. Steven Semrau, an alleged perpetrator of medical fraud, intended to rely on expert testimony that would draw upon fMRI evidence. The evidence was presented as a scientifically advanced alternative to conventional credibility assessment and polygraph methods[47].

Issue: Whether fMRI-based lie detection meets the criteria for reliability set out in Daubert and the Federal Rules of Evidence 702.

Holding: The evidence was excludedThis was because most of the research that had been done had been carried out under controlled conditions and not real-life situations. There were also questions about accuracy and error rates.

Analysis: This is considered to be the most important decision by the American courts on neuroscientific lie detection. The judiciary insisted that scientific novelty must be matched by tested reliability.

Importance: Semrau became a landmark rejection of premature neuroscience. It signalled that in the guilt phase of criminal trials, courts remain wary of technologies claiming to "read the mind" of an accused person.

Case 2 – R v Reed and Reed (United Kingdom)

Facts: The case dealt with low-template DNA profiling, an emerging forensic technology able

[46] Francis X Shen, 'Neuroscience, Mental Privacy, and the Law' (2013) 36 *Harvard Journal of Law & Public Policy* 653.
[47] United States v. Semrau.

to examine small biological samples. Issues were raised concerning contamination, stochasticity, and the level of scientific development for use in criminal cases[48].

Issue: Whether a relatively new scientific technique should be admitted before its operational boundaries were clearly understood.

Holding: Court of Appeal has agreed that such evidence can be admitted provided all the proper thresholds have been observed.

Analysis: The court did not reject innovation outright. Instead, it adopted a calibrated approach: science is admissible when confined within demonstrated limits.

Importance: The lesson for neuroscience is direct. Courts need not ban emerging tools, but they must insist on validated boundaries, quality controls, and honest disclosure of uncertainty.

Case 3 – BEOS / Brain Fingerprinting Matters (India)

Facts: BEOS, brain mapping, and other similar methods were employed in India during the investigation of criminal cases. They claimed to reveal the existence of "experiential knowledge," through brain activity while listening to stories that were relevant to the criminal offense. Some investigators argued that recognition patterns indicated participation in criminal events.[49]

Issue: Whether such techniques were scientifically reliable and constitutionally permissible, especially when administered without genuine consent.

Holding: It is stated in the case of Selvi v. State of Karnataka that compulsory narco-analysis, polygraph, and brain mapping tests violate the rights of protection from self-incrimination and freedom of personhood. The Court also acknowledged doubts about scientific reliability[50].

Analysis: The controversy exposed the danger of admitting forensic neuroscience before robust validation.

Importance: Indian BEOS matters demonstrate that neuroscience is not only an evidentiary issue but also a civil liberties issue involving consent, privacy, and due process.

Case 4 – Albertani (Italy)

Facts: Italian courts attracted international attention in the Albertani matter, where the defendant's sentence was reportedly reduced after consideration of psychiatric evidence, brain abnormalities, and low-activity MAOA genetic factors associated in some studies with

[48] R v Reed and Reed.
[49] Nita A Farahany, 'Incriminating Thoughts' (2012) 64 *Stanford Law Review* 351.
[50] Selvi v. State of Karnataka.

aggressive tendencies[51].

Issue: Whether biological predispositions and neurological impairment may reduce moral blameworthiness at sentencing.

Holding: The court treated such evidence as relevant to mitigation rather than exoneration.

Analysis: Unlike systems focused sharply on admissibility contests, the Italian approach reflected a more open engagement with behavioural science in sentencing.

Importance: This case demonstrates the use of a biologically based sentencing framework in which neuroscience complements judicial discretion.

6. Ethical and Constitutional Concerns

The growing prevalence of neuroscience-based evidence in criminal cases brings up questions other than those about admissibility and reliability. This implies that the principles of evidence and ethics of criminal law can also be challenged by neuroscience.

6.1 Free Will vs Determinism

The traditional presupposition of the criminal law system was that individuals are free moral agents who can differentiate between legal and illegal acts. Such notions as mens rea, intentionality, recklessness, and culpability are based on this assumption. But often, neuroscience explains a person's behavior through brain wiring, genetics, traumas, substance abuse, and lack of self-control. If criminal conduct is substantially influenced by biological mechanisms, questions arise as to whether punishment should remain primarily retributive[52].

This does not imply that neuroscience negates responsibility. It should be noted that most researchers consider legal responsibility to be a normative notion rather than a scientific one. However, neuroscience-based explanations can make overly simplified views of criminal culpability less popular[53].

6.2 Mental Privacy / Cognitive Liberty

Brain data has been described as the "last private frontier" because it may reveal thoughts, memories, emotional reactions, recognition patterns, or predispositions that individuals have

[51] Deborah W Denno, 'Courts' Increasing Consideration of Behavioral Genetics Evidence in Criminal Cases: Results of a Longitudinal Study' (2011) 61 *Michigan State Law Review* 967.
[52] Joshua Greene and Jonathan Cohen, 'For the Law, Neuroscience Changes Nothing and Everything' (2004) 359 *Philosophical Transactions of the Royal Society B* 1775.
[53] Stephen J Morse, 'Brain Overclaim Syndrome and Criminal Responsibility: A Diagnostic Note' (2006) 3 *Ohio State Journal of Criminal Law* 397.

never chosen to disclose.

It has also raised questions about the right to control access to one's own mental processes, which is known as cognitive liberty. Criminal procedure may therefore need stronger safeguards where the State seeks evidence derived from the mind rather than the body[54].

6.3 Equality Risks

The use of neuroscience to determine that a particular group is naturally predisposed to violent tendencies, impulsiveness, or reoffending might simply provide scientific cover for historical bias[55].

Additionally, access to neuroscience defenses is dependent upon one's financial status. Defendants with money will hire experts who will conduct brain scans and prepare psychological reports, but defendants without money will be unable to afford such services. There is thus an inequality in the ability to obtain the benefits of science[56].

6.4 Self-Incrimination Issues

Compelled neuroscientific testing may also conflict with constitutional protections against self-incrimination. Traditional legal doctrine often distinguishes physical evidence from testimonial compulsion. However, brain-based techniques blur that boundary. If a test seeks to reveal recognition, memory, deception, or internal knowledge, it may effectively force a person to communicate through neural responses[57].

This problem was solved in Selvi vs. State of Karnataka, in which the Indian Supreme Court declared that compulsory narcoanalysis, polygraph test, and brain-mapping amounted to a violation of constitutional rights.

Neuroscience could be of great assistance, but it would be upon constitutional democracies to ensure that in the search for truth, these values do not suffer any harm.

[54] Marcello Ienca and Roberto Andorno, 'Towards New Human Rights in the Age of Neuroscience and Neurotechnology' (2017) 13 *Life Sciences, Society and Policy* 5.
[55] Francis X Shen, 'Neuroscience, Mental Privacy, and the Law' (2013) 36 *Harvard Journal of Law & Public Policy* 653.
[56] Deborah W Denno, 'The Myth of the Double-Edged Sword: An Empirical Study of Neuroscience Evidence in Criminal Cases' (2015) 56 *Boston College Law Review* 493.
[57] Nita A Farahany, 'Incriminating Thoughts' (2012) 64 *Stanford Law Review* 351.

8. Conclusion

There is now a new aspect brought about by the evidence of neuro-scientific research that provides insights regarding cognitive processes, behavioral control, brain damage, and developmental abilities which have been incorporated into the criminal proceedings. There has been an increase in the number of cases that involve the use of neurological evidence in court, particularly where there are issues concerning competence, insanity, mitigation during sentencing, and diminished responsibility.

Each jurisdiction offers unique insights into the matter: the US stresses gatekeeping based on reliability criteria, the UK values methodological clarity, India places emphasis on constitutional protection from forced testing, while European examples demonstrate greater usage in mitigation during sentencing.

The future development of neurolaw will neither require an uncritical adoption of scientific evidence nor its complete dismissal. Instead, neuroscientific information must be allowed entry into the courtroom solely after careful examination and judicial reasoning. If appropriately regulated, neuroscience can aid in achieving justice; otherwise, it may lead to substituting law for illusionary technology.