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Admissibility of "Raw Neural Data" as Criminal Evidence in Criminal Courts: A Jurisprudential, Legal, and Neuroscientific Analysis

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The growing convergence of neuroscience and criminal law, known as neurolaw, has presented a new challenge regarding the admissibility of "raw neural data" (e.g., EEG signals and brain activity) as criminal evidence in judicial proceedings. This study aims to examine the position of these data within Iran's criminal evidence system, employing a descriptive-analytical method with an interdisciplinary approach to assess the threefold dimensions of scientific, legal, and jurisprudential aspects of the issue. Research findings indicate that from a scientific perspective, raw neural data lacks the necessary validity to serve as independent and conclusive criminal evidence due to high uncertainty, technical challenges in collection and interpretation, and the existence of an "explanatory gap" between purely biological brain activity and criminal intent. From a legal perspective, mandatory reliance on such data contradicts the principles of fair trial, particularly the right to silence, presumption of innocence, and the right to mental privacy. Finally, from a jurisprudential standpoint, the lack of sufficient certainty regarding this evidence renders it subject to the principle of doubt (dara') and prevents the formation of the jurisprudential concept of "judicial knowledge" (ilm al-qadi) required for proving hudud or qisas. The research findings indicate that, in the current state, raw neural data can only be used as supplementary evidence alongside other traditional forms of evidence; its use should be restricted to the preliminary investigation phase and only with informed consent. Therefore, the enactment of stringent regulatory standards and the establishment of specialized neurolaw committees to assess the scientific validity of such evidence is an indispensable necessity.

Keywords: *raw neural data, neurolaw, criminal evidence, mental privacy, judicial knowledge, principle of doubt*

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1. Introduction

In contemporary times, with remarkable advancements in neuroscience, particularly in the fields of brain imaging and precise recording of neural activities, the boundaries between brain science and the criminal justice system have become increasingly intertwined. This emerging field, known as "neurolaw", has posed fundamental challenges to traditional legal and jurisprudential systems, especially regarding the admissibility of "raw neural data" as criminal evidence in criminal courts. Raw neural data, obtained through technologies such as electroencephalography or functional magnetic resonance imaging (fMRI), hold the potential to uncover truths hidden within the defendant's mind that may not manifest in confessions or testimonies.

Therefore, the primary objective of this study is to analytically and interdisciplinarily examine the position

of these data within Iran's criminal evidence system to address the central question: Can raw neural data, considering the country's jurisprudential and legal foundations as well as their inherent scientific challenges, be accepted as an independent or strong corroborative evidence in proving criminal offenses in criminal courts? This necessity arises because traditional criminal law primarily bases its evidence on behavioral and observable evidence, and the introduction of purely biological and internal data necessitates a reevaluation of the principles of fair trial.

Determining the position of these data entails addressing numerous subsidiary questions. From a technical and scientific perspective, it must be examined how challenges related to uncertainty, error rates, and the "explanatory gap" (the gap between purely biological brain activity and criminal intent) affect the validity of neural data in proving *mens rea*. From a legal perspective, the conflict between mandatory reliance on such data and fundamental principles such as the right to silence, presumption of innocence, and the right to mental privacy must be elucidated. Finally, from a jurisprudential standpoint, the role of ambiguous and non-conclusive data in the process of achieving "judicial knowledge" and its relation to the precautionary principle of doubt (*dara'*) will be analyzed.

At best, these data can only be used as supplementary evidence, provided that strict scientific and legal protocols are followed and exclusively alongside other legal evidence. This hypothesis is reinforced by the assumption that the interpretability and inherent error rates of these evidences undermine their scientific validity, and their acceptance without informed consent constitutes a clear violation of the defendant's right to mental privacy.

This research, employing a descriptive-analytical method with an interdisciplinary approach, is structured into three distinct sections using library resources, domestic laws, and reputable scientific articles: the first section addresses the scientific foundations and technical challenges of neural data; the second section analyzes the legal aspects and their compatibility with the principles of fair trial in Iran; and the final section will examine the jurisprudential obstacles and the position of these data within judicial knowledge to ultimately propose necessary legislative and judicial solutions to address this novel challenge.

2. Scientific and Conceptual Foundations of Raw Neural Data in Neurolaw

In this section, we provide a precise definition and classification of the tools used in recording neural activities, the critical differences between primary signals and legally interpreted information, and finally, explain the problematic relationship between brain mechanisms, mind, and criminal behavior from the perspective of legal neuroscience.

2.1. Concept and Types of Neural Data

Neural data refer to quantitative and qualitative information derived from the direct or indirect recording of electrical, chemical, or hemodynamic activities of the brain and nervous system, serving as the foundation for legal neuroscientific analyses.

a) Definition and Types of Raw Neural Data

Raw neural data refer to the initial, minimally processed outputs of devices measuring brain activity. These data are objective in nature but inherently lack direct legal or cognitive meaning. Such data may include electrical voltages, changes in magnetic fields, or localized blood flow variations (Shen, 2013).

The primary tools for recording raw neural data are:

- Electroencephalography (EEG): This method records changes in electrical potential resulting from synaptic activity of neurons from the scalp surface. Raw data consist of continuous and oscillating waves displayed in voltage-time (microvolts per second) (Norian, 2018). The primary application of EEG in neurolaw involves analyzing event-related potentials (ERPs), such as the P300 or P3b components, used to detect the presence of crime-related information in the defendant's memory (Rosenfeld, 2011).
- Functional Magnetic Resonance Imaging (fMRI): This technique indirectly measures neural activity through the detection of changes in blood oxygen levels in different brain regions. Raw fMRI data consist of a series of spatiotemporal volumetric images showing hemodynamic changes during the execution of a task (e.g., responding to lie detection questions) (O'Shea & Murrie, 2014).
- Magnetoencephalography (MEG): This sensitive method records extremely weak magnetic fields

produced by electrical currents in the brain. Raw MEG data possess high temporal resolution and are often used alongside fMRI to more precisely determine the source of brain activity.

2.1.1. *Difference Between Raw Data and Processed or Interpreted Data*

The distinction between raw data and interpreted information in neurolaw is critical, as courts typically deal with interpreted results, while the legal and scientific challenges lie in the processing of raw data. Processed data result from the application of complex statistical algorithms (e.g., noise removal, filtering, or parametric statistical modeling) to raw data to transform them into comprehensible information (e.g., P300 waveforms or statistical maps of brain activity) (Gazzaniga, 2015). Therefore, merely presenting raw data to the court holds no value; meanwhile, interpreted information, due to multiple processing steps, is susceptible to Type I and Type II statistical errors, and its validity depends on the software models used. Consequently, the legal validity of such evidence is not tied to the precision of the device but to the accuracy and general acceptance of the processing methods (Gandy, 2016).

2.1.2. *Relationship Between Mind, Brain, and Criminal Behavior*

The most significant challenge in neurolaw is bridging the explanatory gap that exists between three analytical levels: brain (biological activity), mind (intent, awareness, free will), and behavior (criminal act). Criminal law primarily focuses on the mind level (psychological element), while neuroscience can only record brain-level activity.

- Brain and Criminal Behavior: Research has shown that structural and functional abnormalities in specific brain regions, particularly the prefrontal cortex responsible for impulse control, decision-making, and emotional regulation, are associated with antisocial and aggressive behaviors (Raine, 2013). For example, brain activity studies have demonstrated reduced activity in the prefrontal cortex of psychopathic offenders during ethical evaluations. These findings may be useful in assessing criminal responsibility and the defendant's competency (Soleimani & Mirmajidi, 2020. 40). Despite statistical correlations, neuroscience cannot provide a definitive neural pattern indicating a specific "intent" at the time of the crime. This means that neural evidence can ultimately only state "how the brain functions," but cannot conclusively determine "what intent the individual had at the time of the crime" or whether they possessed free will (Greene & Cohen, 2004). The absence of a causal link prevents neural data from being transformed into evidence for directly proving the psychological element.

3. Scientific Challenges and Reliability of Neural Data

Despite the remarkable potential of raw neural data in illuminating hidden aspects of the mind, their scientific reliability in a judicial context remains highly questionable. One of the most critical challenges is the existence of the "explanatory gap" between recorded biological signals and complex mental phenomena such as intent, will, and awareness. For instance, a specific neural activity pattern in a particular brain region may merely reflect the defendant's anxiety during the test, not an indication of deception or memory related to the crime scene. Moreover, the methods for collecting these data, particularly in noisy and uncontrollable laboratory environments, face challenges such as measurement errors and susceptibility to external factors (e.g., head movement or drug consumption), which can negatively impact the accuracy and reproducibility of results (O'Shea & Murrie, 2014).

This scientific uncertainty undermines the reliability of raw neural data against the stringent standard of "proof beyond a reasonable doubt", which is a prerequisite for criminal judgments. Additionally, the process of converting raw data into interpretable evidence (e.g., brain maps) requires the use of complex statistical algorithms and filtering, which at each stage increases human intervention and the potential for bias. Consequently, many experts believe that until neuroscience can establish a definitive and reproducible causal link between a specific neural pattern and a particular criminal intent, the use of such data should be limited to fields such as diagnosing neurological disorders affecting criminal responsibility, rather than

directly proving the commission of a crime (Nabavi-Fard et al., 2019).

4. The Position of Scientific Data in the Criminal Evidence System

The history of the criminal evidence system demonstrates that courts have gradually, albeit cautiously, paved the way for the acceptance of new scientific evidence. Initially, evidence such as fingerprints and blood typing were accepted as pioneers of scientific evidence. However, the turning point in accepting definitive scientific evidence was the introduction of DNA analysis in the late twentieth century, which, due to its unparalleled accuracy and certainty, effectively became the "queen of evidence" and established a new gold standard for scientific reliability (Krimsky, 2011). In Iranian law, although legal evidence remains confined (e.g., confession and testimony), *ilm al-qadi*—which underpins many judicial rulings—explicitly refers to scientific evidence, particularly in Article 211 of the Islamic Penal Code, granting judges the authority to utilize emerging evidence and presumptions to achieve certainty in their minds. Neuroscience data and neurolaw, in this context, have emerged as a new generation of scientific evidence that, unlike DNA—which identifies the perpetrator—potentially targets the criminal intent and psychological element of the offense. The formal acceptance of scientific evidence in fair trials internationally also adheres to stringent principles based on two fundamental concepts: relevance and reliability. In Iranian law, Article 160 of the Criminal Procedure Code explicitly references "expert theories" and "local investigations," creating a legal foundation for the entry of neuroscience-based evidence. However, the core challenge of neural data (unlike fingerprints or DNA, which involve physical certainty) lies in its inability to readily satisfy the reliability criterion due to interpretive uncertainty and the explanatory gap between neural patterns and criminal intent, confining it merely to the status of judicial presumptions. Ultimately, the analysis indicates that the current position of neuroscience within the evidence system is as a supplementary tool to strengthen *judicial knowledge* in verifying confessions or assessing the defendant's criminal responsibility—not as an independent basis for directly proving the commission of a crime (Shabazi & Mirhoseini, 2020).

5. Legal Feasibility of Relying on Neural Data: Criteria for Accepting Scientific Evidence

The acceptance of any new scientific evidence in criminal courts requires navigating rigorous legal and technical filters based on two core criteria: scientific validity and relevance to the crime. Scientific reliability is assessed through the methodology of data generation and its alignment with accepted scientific standards (e.g., the Daubert standard in U.S. law). For raw neural data, the challenge is that while capable of recording brain activity, no definitive scientific consensus exists on interpreting these data as direct evidence of criminal intent or crime-related memory—directly undermining their reliability for proving the crime. Courts typically accept scientific data only when measurement error is minimized and reproducible information is provided (Krimsky, 2011). Conversely, relevance requires that the evidence directly relate to the case facts and criminal elements; for instance, the mere presence of a functional brain disorder in the defendant does not inherently imply lack of criminal responsibility at the time of the offense unless an expert establishes a causal link between the disorder and criminal behavior.

Beyond technical considerations, the most significant legal barrier to accepting raw neural data is the protection of defense rights and mental privacy. Extracting mental information, even via non-invasive technology, creates a serious conflict with the defendant's right to silence and the principle of non-compulsory self-incrimination (Article 38 of the Iranian Constitution). This challenge has spurred serious studies on the necessity of new legal frameworks titled "right to cognitive privacy" or "right to mental integrity" to prevent misuse of neural technologies for "mind-reading" (Safaripour & Saadati, 2021). Humanistic analysis of this issue reveals that while neural technologies may aid truth discovery, they must not come at the cost of violating individuals' mental dignity and freedoms. Consequently, the acceptance of such evidence in courts should be restricted to cases where the defendant has provided informed, voluntary consent, and data are used solely for assessing criminal responsibility (not proving the commission of the crime), thereby balancing truth-seeking with the protection of fundamental defendant rights.

6. Legal and Ethical Challenges and Comparative Perspectives

The use of neural data in courts, beyond technical and scientific considerations, confronts profound legal and ethical challenges directly targeting the principles of fair trial and fundamental human rights.

6.1. Legal and Ethical Challenges

One of the most critical ethical concerns is the risk of violating freedom of thought and conscience (the principle of mental freedom). Neural data potentially grant access to an individual's mental content and cognitive processes, conflicting with the foundational principle of freedom of thought. This concern specifically opposes the concept of mental privacy. Mental privacy refers to an individual's right to protect their cognitive information and processes from collection, use, or manipulation by external parties. Thus, the compulsory extraction of neural data constitutes a violation of an individual's internal security, which has historically been considered inviolable (Ienca & Haselager, 2016).

These challenges become particularly evident in the context of the possibility of compelling defendants to provide neural data. Iranian legal systems and international instruments emphasize the right to silence and the principle of non-compulsory self-incrimination (Article 38 of the Constitution). Legal analysis indicates that compelling a defendant to participate in neural tests (e.g., memory detection tests using brain activity fMRI) amounts to compelling the provision of evidence directly extracted from their mind, potentially constituting a clear case of self-incriminating testimony. Although some argue that neural data are physical and biological evidence rather than verbal statements, since they directly relate to an individual's intent and awareness, they should be afforded legal protections analogous to the right to silence (Safaripour & Saadati, 2021).

Furthermore, the potential for error and misinterpretation of data represents a serious ethical challenge. As previously discussed, raw neural data carry scientific uncertainty, and processing algorithms may be prone to error or bias. Misinterpretation or overestimation of the scientific validity of such data may lead to unjust judicial rulings, violations of fair trial rights, and ultimately, the conviction of innocent individuals (Faqih et al., 2022). This underscores the necessity for establishing independent expert bodies and training judges to accurately assess the validity of such evidence.

6.2. Comparative Perspective

The approach of developed legal systems toward neural data has largely been characterized by caution and skepticism. In the United States, the acceptance of scientific evidence requires adherence to the Daubert standard, which emphasizes testability, error rates, peer review, and general acceptance within the scientific community. U.S. courts have broadly and formally rejected neurotechnologies such as brain activity-based lie detection as conclusive evidence, deeming them insufficiently reliable. Instead, such evidence has primarily been used in limited contexts for assessing psychological capacity and mitigating criminal responsibility during sentencing, not for proving the commission of a crime. Similarly, in Europe, the Council of Europe and the European Union have shown significant concern for the ethical and human rights dimensions of neurotechnology, emphasizing the necessity of legal frameworks to protect "neuro-rights," particularly mental privacy and cognitive integrity (Ienca & Haselager, 2016, p. 32). This comparative approach reveals a global consensus on the scientific uncertainty of neural data and the imperative to safeguard cognitive freedoms against intrusion by the criminal justice system.

The approach of advanced legal systems toward the use of neural data (neurotechnologies) in criminal courts has predominantly involved stringent caution and rejection of such evidence as conclusive. This caution stems from scientific challenges (lack of reliability) and ethical concerns (violation of defense rights).

a) International Case Studies (United States, Europe, India)

- **United States**: Federal and state courts have largely refrained from broadly accepting evidence based on techniques such as lie detection or P300-based memory detection (popularly known as "Brain Fingerprinting"). The primary reason for rejection is non-compliance with the Daubert standard. This standard defines the criteria for scientific evidence acceptance based on testability, error

rates, peer review, and general acceptance among experts (Shen, 2013). U.S. judges have argued that these techniques lack acceptable error rates and sufficient general acceptance among specialists for directly proving criminal intent. Nevertheless, neural evidence has been used in limited, non-conclusive contexts—such as mitigating criminal responsibility or assessing the defendant's mental health during sentencing (e.g., determining competency for execution).

- **European Union**: European countries have focused more on the ethical and human rights dimensions of neurotechnology. The Council of Europe and the European Parliament have expressed serious concerns about protecting "neuro-rights," particularly the right to mental integrity and mental privacy. The dominant approach involves developing preventive ethical and legal frameworks to prevent misuse of such data by judicial or state authorities (Ienca & Haselager, 2016). The European approach centers on informed, voluntary consent from the defendant, with compulsory use virtually entirely rejected.
- **India**: In contrast, India presents a unique historical example. In 2008, the Supreme Court of India in Maharashtra accepted brain mapping results in a murder case. However, this practice was explicitly rejected by the Supreme Court of India in 2010, which declared that lie detection or brain mapping tests, without the defendant's consent, constitute a clear violation of the principle of non-compulsory self-incrimination and contravene the Indian Constitution (Sharma, 2013).

b) Judicial Practices and Expert Views in Neuro-forensics

Expert opinions in neuro-forensics strongly advocate caution in accepting raw neural data. These experts emphasize that current knowledge cannot bridge the explanatory gap between neural activity and conscious will. In other words, neural evidence can only demonstrate correlation, not causation.

International judicial practices have concluded that neural data currently lack the necessary certainty to establish guilt and therefore should not be used as independent criminal evidence. Their application is generally restricted to:

- Assessing the defendant's mental state
- Diagnosing neurological conditions that may mitigate criminal responsibility
- Supporting or undermining the defendant's claims during investigative phases, not conclusive proof.

The comparative analysis indicates that Iran's legal system, given its strict jurisprudential requirements for criminal evidence (e.g., the *dara'* principle) and legal principles (right to silence), must adopt a similarly cautious approach.

7. Analysis of Iranian Law Regarding Neural Data

The 2013 Criminal Procedure Code (enacted in 1392 of the Iranian calendar) defines criminal evidence in Article 160 as including confession, testimony, oaths, and *ilm al-qadi*, without explicitly mentioning "scientific evidence." However, the "expert theory" referenced in the "and" clause of this article, and "clear and conclusive circumstances" in Article 211 of the Islamic Penal Code, are recognized as foundations for *ilm al-qadi*. This legal framework provides a basis for neuroscience findings to enter the *ilm al-qadi* process as "corroborative or scientific presumptions" to strengthen or weaken other evidence, but not as independent criminal evidence (Shamlou & Norouzi, 2021). The core issue is that lawmakers have not established clear standards for accepting this new scientific evidence or defining its validity, leaving full discretion to judges.

Current analysis reveals that the absence of explicit legal provisions and specialized criteria creates a dual risk. On one hand, judges unfamiliar with the nature and uncertainty of neural data may overvalue it, treating it as "absolute scientific truth." On the other hand, they may reject it entirely due to its non-compliance with traditional evidence norms or perceived illegality. This legal vacuum undermines the defendant's defense rights and the principle of fair trial by reducing transparency and predictability in scientific evidence usage. Consequently, until legal amendments or specialized regulations are enacted, neural evidence can only function within the *ilm al-qadi* framework as an advisory, supportive expert theory.

7.1. *Examination of the Principle of Free Will and the Principle of Mental Integrity*

The principle of free will and conscience is a foundational concept in human rights law and is deeply rooted in Iranian constitutional and jurisprudential principles. A key manifestation of this principle in criminal proceedings is the principle of mental integrity, which is linked to the right to silence and the principle of non-compulsory self-incrimination (Article 38 of the Constitution). Extracting raw neural data (particularly for detecting memory or criminal intent) constitutes direct intrusion into an individual's cognitive and thought processes. This raises the legal challenge: does this action constitute an intrusion into the individual's private life or mental sphere, and are these data "physical evidence" justifying compulsory provision (like blood or DNA samples), or "testimonial evidence" requiring protection under the right to silence (Shabazi & Mirhoseini, 2020)? Legal scholars argue that since neural data directly relate to cognitive content (intent and awareness), they must fall under testimonial evidence.

Therefore, any attempt to collect neural data from a defendant without their informed, voluntary consent constitutes a clear violation of mental freedom and the principle of mental integrity. Consent alone for testing is insufficient; the defendant must be fully aware of the nature of the information to be extracted from their mind and the legal consequences. While the legislator's goal is truth discovery, this objective cannot be justified by tools that directly violate an individual's fundamental rights. Thus, Iranian law must, based on Article 38 of the Constitution, reject any compulsory reliance on neural data as evidence derived through coercion, psychological pressure (e.g., fear of punishment), or torture; otherwise, we will witness a severe violation of cognitive freedoms.

7.2. *Interpretation of Neural Data as Scientific Presumption, Not Conclusive Evidence*

Given the scientific challenges raised (e.g., high error rates and the explanatory gap), the optimal legal position for neural data in Iranian law is to interpret them as a "scientific presumption" or "judicial presumption," not as "conclusive criminal evidence." In Iranian law (Article 160 of the Criminal Procedure Code), *qarā'in* (plural of *qarīnah*) and *amārāt* are evidentiary elements that indirectly guide the judge toward truth discovery and serve only to corroborate other evidence. Due to their probabilistic nature, neural data can never serve as the sole basis for a conviction without supporting strong evidence (e.g., confession or testimony), particularly in crimes carrying severe penalties (hudud or qisas) where jurisprudence demands certainty (Faqih et al., 2022). This approach safeguards judicial justice. Accepting neural data solely as a scientific presumption enables the judge to leverage scientific advancements for deeper case understanding and assessment of the defendant's claims without succumbing to the illusion of technological certainty. The judge must recognize that a scientific presumption merely indicates probability, and *ilm al-qadi* (judicial knowledge) is achieved only when a combination of such presumptions, alongside legal evidence, leads to 100% certainty. Thus, Iranian law can prevent overreliance on non-conclusive scientific evidence by emphasizing the advisory and probabilistic nature of these data, thereby upholding the principle of *dara'* (principle of doubt), which mandates that punishment not be issued in cases of doubt.

7.3. *Need for a Specialized Regulation for Evaluating Neural Evidence in Courts*

Given the technical and interdisciplinary nature of neural data and the existing legal vacuum, Iranian law urgently requires the drafting of a specialized regulation or guideline for evaluating and accepting such evidence in courts. This regulation must establish standards beyond mere "expert opinion," explicitly defining protocols for data collection (standardizing experimental environments), acceptable minimum error rates for analytical algorithms, specialized qualifications for legal neuroscience experts, and the necessity of obtaining informed consent (Shamlou & Norouzi, 2021, p. 89). Such a regulation could serve as a benchmark for scientific evidence acceptance in other legal systems while preventing judicial subjectivity or misuse of unreliable evidence.

The analysis of this regulatory need is critical for maintaining the principle of equal arms in criminal proceedings. Without specialized standards, the defendant cannot effectively challenge the neural evidence presented by the prosecution. Drafting a specialized regulation, by establishing transparency and consistent procedures, not only ensures fairer trials but

also reduces error rates in evidence presentation by compelling experts to adhere to the highest scientific standards. This legal measure represents an essential step toward aligning Iran's criminal law with rapid advancements in neuroscience without compromising fundamental defense rights.

8. Legal and Jurisprudential Analysis of the Admissibility of Neural Data

This section analyzes the admissibility of neural data within Iran's legal and jurisprudential framework and the challenges it poses to principles of fair trial.

8.1. Compatibility with Legal Evidence in Iranian Criminal Law

The Islamic Penal Code (Article 211) and the Criminal Procedure Code (Article 160) do not explicitly address scientific evidence. Criminal evidence in Iran is confined to traditional forms (confession, testimony, oaths, *qasāmah*) and *ilm al-qadi*. *Ilm al-qadi*, which plays a central role, is based on "clear and conclusive circumstances" of the case, creating a legal pathway for new scientific evidence. Expert theory (under which neural data fall) is recognized as one of the most important foundations of *ilm al-qadi*, yet it is ultimately treated merely as a *presumption* or *qarīnah*, not as independent evidence (Shamlou & Norouzi, 2021). Consequently, neural data are not formally classified as legal evidence but may serve as a supportive element in the judge's mind to achieve certainty. Under current law, neural data cannot serve as conclusive evidence for conviction but may be used *advisory* during preliminary investigations (e.g., to strengthen or weaken investigative hypotheses and guide the investigation path). However, even in this phase, their use must respect the defendant's human rights. Utilization of such evidence must remain cautious, under judicial supervision, and solely for evidence collection—not for final proof of guilt—to prevent overvaluation of non-conclusive scientific evidence in the judicial process.

8.2. Analysis of Neural Data as a Judicial Presumption

Neural data, due to their lack of certainty and the explanatory gap between neural patterns and criminal intent, can at best be regarded in Iranian law as a *judicial presumption*. Judicial presumptions are evidentiary elements that merely create a probability and guide the judge toward truth discovery. Transforming a scientific presumption (e.g., neural data) into a strong, effective presumption that aids *ilm al-qadi* requires two essential conditions: first, high scientific reliability (which remains seriously contested for neural data, particularly in memory detection or deception analysis); and second, a strong logical connection to the crime facts that can reasonably increase the probability of the defendant's commission of the offense (Shabazi & Mirhoseini, 2020). This analysis indicates that the judiciary must establish stringent standards to determine the extent to which such scientific presumptions aid *ilm al-qadi*. Until neural data error rates significantly decrease and broad scientific consensus on their interpretation is achieved, they cannot be considered conclusive presumptions. Therefore, judges must approach such data with skepticism and rely on them only as corroborative elements alongside other strong evidence (e.g., valid confession or credible testimony), collectively generating a body of certainty in their minds. This approach prevents the elevation of technical and probabilistic evidence over judicial truth, which would undermine justice.

8.3. Human Rights Challenges and Principles of Fair Trial

The acceptance of neural data raises fundamental human rights challenges and conflicts with principles of fair trial. The most significant of these is the conflict with the right to silence and presumption of innocence. Article 38 of the Constitution explicitly prohibits any compulsion to confess or testify against oneself. If neural data collection is conducted compulsorily, this action may constitute compulsion to provide evidence directly extracted from the defendant's mind, thereby qualifying as self-incriminating testimony—even if the evidence possesses physical characteristics (Faqih et al., 2022). Neural data ultimately pertain to an individual's intent and awareness and cannot be reduced to a physical object like fingerprints, which fall outside the protection of the right to silence.

Furthermore, the extraction of such data constitutes a violation of mental privacy. Mental privacy, as a novel right, guarantees an individual's right to protect their cognitive information and processes from external interference. In light of international conventions and

modern legal experiences (e.g., debates on "neuro-rights" in Chile), it is imperative that Iranian criminal law formally recognize the necessity of legislating a "right to mental privacy." Analysis of this conflict reveals that the defendant's defense rights against new scientific evidence are preserved only if neural data collection is strictly contingent upon the defendant's informed, explicit, and voluntary consent, with no possibility of misuse for "mind-reading." Safeguarding this privacy is not merely an ethical obligation but a fundamental prerequisite for ensuring human dignity in the judicial process.

8.4. Jurisprudential Obstacles

From a jurisprudential perspective, the primary obstacle to accepting raw neural data lies in its relationship with the role of *ilm al-qadi* (judicial knowledge) and the conditions for its validity. In Shia jurisprudence, *ilm al-qadi* is a strong form of evidence, but its validity is achieved only when supported by reliable and conclusive evidence. Given the scientific uncertainty of neural data and their potential for error, reliance solely on such evidence cannot establish the required religious certainty for issuing a verdict (Shamlou & Norouzi, 2021). Particularly in crimes carrying severe penalties (hudud or qisas), jurisprudence emphasizes strict caution and avoidance of any doubt.

This jurisprudential caution is linked to the *dara'* principle (hudud are invalidated by doubt). *Dara'* stipulates that when doubt or uncertainty exists regarding the elements of a crime or its attribution to the defendant, the punishment (especially hudud) is invalidated. Since neural data, due to their scientific uncertainty, inherently carry a degree of doubt and probability, they fall under the *dara'* principle and prevent the judge from attaining the necessary certainty for imposing hudud punishments. Jurisprudential analysis dictates that until the scientific certainty of neural data reaches the level of other conclusive evidence (e.g., full confession), they cannot serve as the basis for a conviction. Instead, they may only function as advisory evidence in cases of mitigating criminal responsibility (e.g., insanity or impaired will) or in less severe ta'zir crimes.

9. Conclusion

This study's interdisciplinary analysis of the admissibility of raw neural data in Iranian criminal courts demonstrates that this neurotechnological phenomenon, while offering unprecedented potential for truth discovery and deeper assessment of the psychological element of crime, faces serious scientific, legal, and ethical limitations that prevent its acceptance as independent and conclusive criminal evidence. Scientific limitations stem from the "explanatory gap" between purely biological brain activity and criminal intent, coupled with high error rates in interpreting raw data. Legal and jurisprudential obstacles arise from conflicts with fundamental principles such as the right to silence, non-compulsory self-incrimination (Article 38 of the Constitution), and jurisprudential caution in imposing severe punishments (*dara'* principle).

The final conclusion supports the research hypothesis: in the current context, neural data can only be utilized as an advisory scientific presumption or *qarīnah* to strengthen *ilm al-qadi* and assess criminal responsibility, contingent upon the defendant's informed and voluntary consent.

To responsibly and balancedly address these emerging challenges, Iran's legal system requires reform and the establishment of specialized frameworks. The first recommendation is the drafting of a specific legal framework to regulate, interpret, and accept such data. This framework should, in the form of a specialized regulation or judicial guideline, establish standards analogous to the "Daubert standard" in comparative law for evaluating the accuracy and reliability of neural evidence—standardizing error rates of experts and data collection protocols. The aim is to prevent judicial subjectivity and overvaluation of non-conclusive evidence.

The second recommendation emphasizes the necessity of interdisciplinary collaboration among legal experts, ethicists, and neuroscientists. Resolving neurolaw challenges depends solely on continuous, shared dialogue among these three fields. Establishing "specialized neurolaw committees" within the judiciary—comprising judges, legal scholars, jurists, and neuroscience experts—can facilitate impartial, technical, and ethical evaluation of neural evidence and define its acceptable boundaries. This collaboration will enhance

the legal community's awareness of the scientific limitations of these tools and prevent hasty judgments.

Ultimately, neurotechnological advancements underscore the imperative of recognizing "mental privacy" as a new manifestation of privacy rights in future criminal law. Since raw neural data directly intrude upon an individual's cognitive content and will, lawmakers must, inspired by comparative law, formally recognize the individual's right to "mental integrity" and "cognitive freedom," and strictly condition any access to neural data on the defendant's explicit consent and a specific, limited judicial order. This legislative step ensures that truth-seeking efforts do not violate the fundamental dignity and cognitive freedoms of the defendant, positioning Iran's legal system to align with human rights challenges in the era of modern neurotechnology.

Authors' Contributions

Authors contributed equally to this article.

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In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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