Neurocriminology and evidentiary standards in Indonesian courts

Zul Khaidir Kadir & Nur Fadhilah Mappaselleng

Neurocriminology and evidentiary standards in Indonesian courts

Zul Khaidir Kadir[*] & Nur Fadhilah Mappaselleng

Faculty of Law, Muslim University of Indonesia, Jl. Urip Sumoharjo KM.05, Kec. Panakkukang, Kota Makassar, Sulawesi Selatan 90231, Indonesia
*e-mail: zulkhaidir.kadir@umi.ac.id

ABSTRACT

According to the Indonesian Code of Criminal Procedure, the evidentiary system in criminal law remains grounded in the principle of individual responsibility, which presumes free will. However, the incorporation of neurocriminological approaches into legal practice introduces ontological and epistemological conflicts that have not been systematically addressed by existing legal frameworks. This study aims to examine the tension between the concept of individual criminal liability and the deterministic framework of neuroscience and evaluate the admissibility of neuroscientific evidence within the criminal evidentiary system. This study employs a normative legal method with a conceptual approach. The findings indicate that Indonesia's criminal law lacks a conceptual framework capable of bridging the gap between moral culpability and biological vulnerability, thereby risking a loss of coherence in the attribution of legal responsibility to offenders. Furthermore, the absence of normative and procedural mechanisms for assessing the validity, limits, and relevance of neuroscientific evidence creates epistemic asymmetries and opens the door to bias in judicial proceedings. Under such conditions, integrating neuroscience into the legal system risks generating ambiguity in determining liability and undermining the principle of substantive justice. Accordingly, a normative reconstruction of evidentiary law is required as a foundational step to ensure legal consistency in responding to scientific advances.

Keywords: criminal liability; evidentiary standards; neurocriminology.

priviet lab.
RESEARCH & PUBLISHING

1. INTRODUCTION

Criminal law is constructed upon the assumption that individuals possess the freedom to choose and are accountable for the consequences of their choices (Jumantoro & Firdausy, 2025). The normative framework of Indonesia's criminal justice system presumes that offenders can understand their actions and exercise self-control in accordance with legal norms. Sentencing is administered based on the principle of individual responsibility, which requires a causal relationship between intent, volition, and action (List, 2024). Within this structure, the legal subject is interpreted through a normative rather than a biological lens. This model also implies that the evidence presented in court must explain events through juridical reasoning, not merely through scientific determinants.

As scientific knowledge advances, explanations of criminal behaviour have begun to incorporate interdisciplinary perspectives, including neuroscience (Serban, 2025). Neurocriminology, a convergence of neuroscience and criminology, seeks to identify correlations between brain structures, neurological functioning, and deviant behavioral tendencies. Several studies have identified links between abnormalities in the prefrontal cortex and increased impulsivity, aggression, and a diminished decision-making capacity. When such biological findings are used as a basis for evaluating criminal culpability, a tension arises between the deterministic framework of neuroscience and the legal principle of individual accountability. This tension calls for a philosophical and normative inquiry into the position of human agency within the evidentiary structures of criminal adjudication.

Over the past two decades, the use of scientific evidence in courtrooms has become increasingly prevalent, including digital evidence, DNA analysis, and forensic psychology (Rao et al., 2023). In several jurisdictions, neuroscientific data have been introduced as part of legal defenses, particularly in arguments involving mental disorders or claims of diminished legal capacity. Cases such as *Mobley* in the United States and *Waldroup* in Italy have sparked broader debate over the admissibility and probative weight of neuroimaging results in determining criminal liability (Khalid et al., 2024). These developments suggest that courts are gradually moving beyond conventional legal facts and beginning to engage with biological data that purports to explain the defendant's behavior.

However, this trend has not developed systematically in Indonesia. Although psychiatric arguments have occasionally been employed in defence strategies, neuroscience remains peripheral to the evidentiary structures of criminal trials. The Indonesian Code of Criminal Procedure (KUHAP) contains no specific provisions governing the admissibility of such evidence. Consequently, the legal status of neuro-evidence remains ambiguous. Judges tend to defer to expert testimony without clear guidelines regarding scientific validity, methodological rigor, or the boundaries of expert authority. This institutional gap reveals a structural imbalance between the technological capacity to generate scientific data and the legal system's preparedness to assess and regulate such data.

Furthermore, the Indonesian judicial system lacks procedural mechanisms to test the scientific credibility, reliability, and academic acceptability of the submitted evidence. There is no equivalent to the *Daubert Standard* adopted in the United States, which allows judges to evaluate the scientific methodology and foundational legitimacy of evidence before it is admitted at trial (Dias & Jacobsen, 2023). In practice, neuroscientific evidence is often treated as a by-product of expert opinion rather than as objective data with its own epistemic status. Reliance on personal authority instead of methodological scrutiny exposes judicial decisions to subjective interpretations, thereby undermining the integrity of verdicts. In the absence of institutional safeguards, the use of scientific technology risks becoming arbitrary and unaccountable.

Another challenge arises from the limited epistemological awareness of law enforcement officials and legal practitioners regarding the distinction between scientific data and legal proof. In neuroscience, fMRI or EEG results are probabilistic and subject to margins of error that must be interpreted within a scientific framework, not through the lens of legal certainty (Beam et al., 2021). The gap between scientific validity and legal probative force has not been methodologically addressed (Rosenzweig, 2022). Courts demand definitive conclusions, whereas neuroscience offers probability ranges. This misalignment introduces interpretive risks when neuroscientific results are used to support or negate legal responsibility.

These conditions reveal an evolving evidentiary landscape that Indonesia's positive legal system has not adequately addressed. Scientific advancement is outpacing the legal system's capacity to adapt, creating a disjunction between the biological understanding of behavior and the moral assumptions embedded in the legal doctrine. Without a coherent conceptual and procedural foundation, the judicial acceptance or rejection of neuroscientific evidence becomes inconsistent and vulnerable to bias. This poses a serious threat to the substantive fairness of criminal adjudication.

An additional issue concerns the lack of clear boundaries between scientific validity and legal relevance in the use of neuroscientific data (Pernu & Elzein, 2020). If courts are to consider brain scans as either exculpatory or aggravating evidence, a legal standard must be established to ensure that such data is credible, measurable, and protected from manipulation. However, in the absence of such normative and procedural tools, judges are left without a reliable framework to assess the evidentiary strength of these submissions. This uncertainty creates opportunities for technological misuse and undermines procedural safeguards, such as the due process of law.

This research is necessary to address the challenges of integrating neuroscience into Indonesia's criminal justice system, which currently lacks the normative and procedural infrastructure to manage such integration effectively. Without a critical understanding of the epistemological and ontological implications of neurocriminology in evidentiary practice, the legal system risks incorporating scientific technologies without adequate regulation. These consequences affect not only the quality of judicial decisions but also the foundational concept of legal responsibility, namely, the pursuit of justice.

Some prior studies have explored the relationship between neuroimaging and judicial outcomes, particularly regarding the use of fMRI in sentencing and mitigation. However, most of these studies originate from jurisdictions that have already developed procedural standards to evaluate scientific evidence in court (Perricone et al., 2022). In Indonesia, systematic research examining the role of neurocriminology in the evidentiary system, in terms of legal responsibility or evidentiary admissibility, is lacking. This gap underscores the need for a study that not only clarifies but also interrogates the legal system's readiness to engage with biological determinants in evaluating criminal liability.

This study aims to address two primary issues: first, the conceptual tension between deterministic approaches in neurocriminology and the principle of individual accountability in Indonesian criminal law; second, the evaluation of legal evidentiary standards as they relate to neuroscientific evidence. The contribution lies in developing an analytical framework for assessing the position of neuro-evidence within criminal law and proposing conceptual and procedural foundations that may inform future legal reform. The findings of this study may serve as a reference point for the formulation of more adaptive procedural policies in line with advances in scientific knowledge.

2. METHODOLOGY

This study employs a normative legal research approach. Normative legal research examines legal norms, rules, and principles in statutory regulations. This study adopts a conceptual approach, focusing on the analysis of legal concepts, principles, and theories relevant to the subject matter. In this context, a conceptual approach is used to explore the tension between the principle of individual criminal responsibility and the deterministic perspective in neurocriminology. Additionally, it is used to assess the position of scientific evidence within the procedural structure of criminal law and the conceptual boundaries between scientific validity and legal probative force.

The data in this study were collected through library research and subsequently analyzed qualitatively and presented descriptively. Primary legal materials include relevant statutory provisions, such as the Indonesian Penal Code (KUHP) and the Indonesian Criminal Procedure Code (KUHAP). Secondary legal materials consist of scholarly works from journals, books, and official documents that discuss criminal liability, evidentiary law, and the theoretical development of neurocriminology. All data were subjected to qualitative analysis using descriptive-analytical methods. The analytical process involved identifying legal issues, examining relevant legal principles and concepts, and constructing normative legal arguments to address the identified problems of the study.

3. RESULT AND DISCUSSION

3.1. Ontological Dilemma: Is the Brain Criminal?

The classical conception of a legal subject in criminal law is predicated on the existence of free will as the foundation of accountability. An offender is viewed as an individual who consciously chooses to commit an unlawful act and is therefore subject to moral and legal responsibility (Kadir & Mappaselleng, 2025). In this doctrine, culpability is not merely the outcome of physical actions but an expression of morally reprehensible intent. Indonesian criminal law adopts this position through the principle of *nulla poena sine culpa*, which underpins general penal doctrine (Nugroho & Eskanugraha, 2023). This framework treats the actor as an autonomous and rational entity detached from any biological determinants or neurological conditions that may influence behavior.

Neurocriminology challenges this normative framework by introducing a biological approach to criminal behavior analysis. Research in this field has identified associations between structural or functional brain abnormalities and increased tendencies towards aggression, impulsivity, or antisocial conduct. For example, damage to the prefrontal cortex has been linked to impaired decision-making, emotional regulation, and behavioral planning (Ouerchefani et al., 2021). If such impairments are chronic and beyond the subject's control, the question arises as to whether the individual truly comprehends the legal consequences of their actions. This argument leads directly to an ontological issue: can criminal responsibility remain valid if the subject is governed by neurobiological factors?

Assuming that deviant behavior can be neurologically explained shifts the locus of culpability from volition to brain circuitry (Darby, 2023). Consequently, responsibility previously grounded in moral agency must be reconsidered through a biological lens. From this perspective, the offender is no longer seen as a fully autonomous moral agent but as a biologically compromised system. Such reasoning risks eroding the moral foundation of criminal punishment by reframing criminal acts as outcomes of neural dysfunction rather than manifestations of intent. This shift in the locus of crime constitutes the core of the ontological dilemma posed by the integration of neurocriminology into criminal law.

A neuroscience-influenced model of accountability also affects how culpability is categorized. If legal systems acknowledge that neurological disorders can diminish an individual's capacity to understand or control their actions, the boundary between responsibility and non-responsibility becomes blurred. Currently, this capacity is usually assessed through psychiatric evaluation, but neurocriminology proposes assessments based on quantitative biological data, such as brain imaging results. This transition is not merely a matter of evidentiary technique, it implicates the ontological question of who qualifies as legally culpable. Should individuals with chronic neurological deficits still be held accountable for their actions?

From the standpoint of Indonesian law, the existing legal system lacks conceptual tools to accommodate such an approach. Neither the Criminal Code (KUHP) nor the Criminal Procedure Code (KUHAP) provides an explicit framework for assessing culpability based on biological parameters. Neurological arguments are typically subsumed under mental disorder defences, evaluated through forensic psychiatry rather than serving as an autonomous basis for liability (Meynen, 2020). This illustrates that the national legal framework continues to treat the legal subject as a fully rational entity and has not yet recognised that biological systems may influence volitional capacity. Without a conceptual revision, neurocriminology's entry into legal reasoning will encounter both logical and normative resistance.

The presence of neuroscientific evidence in courtrooms introduces consequential problems (Mishra, 2024). When biological evidence is invoked to support claims of diminished responsibility, there must be defined parameters for distinguishing legal capacity from neurological incapacity. In the absence of clear guidelines, courts risk admitting deterministic arguments indiscriminately, ultimately relativising criminal liability. If brain damage can negate accountability, then the volitional foundation of the penal structure becomes vulnerable to subordination by biological claims that are not always legally verifiable.

It is important to recognise that the deterministic approach in neuroscience is not absolute. Much neurological data is probabilistic rather than categorical. Abnormalities in specific brain regions may increase the risk of antisocial behaviour but do not directly cause criminal acts. Such correlations cannot

be equated with legal causation. In judicial processes, the burden of proof is prescriptive and oriented toward certainty, while biological data often contains ambiguities. The use of neuro-evidence without a coherent normative framework can destabilise the system of assessing culpability and sentencing.

In response, the criminal law must re-evaluate how it defines the legal subject. This is not to replace the concept of free will with biological determinism, but to create an integrative space where legal and medical understandings can coexist. The legal subject should still be regarded as a moral agent, yet one whose volitional capacity may be affected by specific neurological conditions. Such a reformulation requires clear legal parameters on when and to what extent biological impairments can reduce or eliminate responsibility. Without this, the legal system remains in an ambiguous position accepting scientific input without understanding its boundaries.

3.2. Epistemological Clash: Scientific Evidence vs Legal Proof

A fundamental distinction between law and science lies in their epistemological structures. Law operates through a prescriptive system of socially binding norms, while science progresses through observation, hypothesis, and verification an inherently provisional and revisable process (Setiadi et al., 2021). When scientific data is introduced into legal proceedings, it brings together two epistemic frameworks that are not inherently compatible. In criminal justice, proof is governed by the principle of certainty and judicial conviction (Dmytrrieva, 2021). In contrast, neuroscientific assessments are probabilistic, inherently ambiguous, and dependent on technical parameters. This disparity forms the foundation of the epistemological tension between scientific validity and the legal standard of proof.

In the context of neurocriminology, data produced by instruments such as fMRI or EEG does not directly establish guilt but indicates patterns of brain activity associated with certain types of behaviour (Alsharif et al., 2021). Such data is not self-explanatory; it requires expert interpretation, statistical modelling, and contextual understanding. Meanwhile, the legal system demands evidence that is direct, relevant, and sufficient to establish guilt beyond reasonable doubt (Smith, 2022). When neuro-evidence is presented in court, judges are confronted with scientifically valid information that may not satisfy legal standards of admissibility or probative force. This misalignment creates an interpretive gap that cannot be resolved without appropriate legal instruments.

Scientific evidence is often presumed to carry a higher degree of epistemic authority than other types of evidence in criminal trials. However, this presumption can be misleading if it is not accompanied by a critical understanding of the nature and limitations of scientific data. In neurocriminology, for instance, fMRI data has notable constraints in both spatial and temporal resolution. Interpreting patterns of brain activation relies on theoretical assumptions that may not be universally accepted. If such data is used to infer intent or legal responsibility, the risk of oversimplification arises contradicting the cautious reasoning required in adjudication. Scientific sophistication does not automatically translate into legal relevance.

Some jurisdictions have responded to this epistemological tension by establishing admissibility standards for scientific evidence. In the United States, for example, the *Daubert Standard* requires that scientific evidence meet four criteria: empirical testing, peer review, known error rates, and general acceptance within the relevant scientific community (Recupero, 2022). Such standards not only shield courts from pseudoscientific claims but also provide a structured framework for judges to assess whether scientific data is suitable for legal use. In the absence of such standards, courts are at risk of accepting scientific claims uncritically and using them in ways that exceed their intended scope.

Indonesia has yet to develop a comparable standard for assessing scientific evidence in criminal trials. The Criminal Procedure Code (KUHAP) recognises five types of evidence: witness testimony, expert testimony, documents, indications, and statements of the accused. Neuroscientific evidence is generally subsumed under expert testimony, even though it originates from objective instruments and methodologies. In practice, the distinction between expert opinion and objective data becomes blurred. Without technical guidelines for evaluating data quality, judges tend to rely on the reputation of the expert rather than scrutinise the underlying methodology. This reliance on personal authority weakens the transparency of the evidentiary process.

The epistemological issues intensify when scientific data is used to justify determinate legal decisions. An fMRI result, for instance, may show decreased activity in a brain region associated with impulse control (Zhukovsky et al., 2020). Yet, such data cannot conclusively establish that this deficit caused a specific criminal act. Neuroscience is not designed to produce legal conclusions; its function is to describe tendencies or vulnerabilities. When judges rely on such data to justify sentencing or acquittal, a shift occurs from legal proof to scientific validation that cannot always be reconciled with normative legal standards.

Another emerging risk is the cognitive effect known as *neuro-realism*, the tendency to perceive brain-based data as more objective, accurate, and neutral than other forms of evidence (Perkins et al., 2023). In courtroom settings, this can introduce bias among judges, prosecutors, and defence counsel, encouraging them to overvalue neurological data despite its questionable legal relevance. This effect is amplified by the persuasive visual appeal of brain scans, which are symbolic representations rather than definitive indicators. Overconfidence in visualised evidence risks reducing the complex question of legal accountability to a medicalised reading.

The admissibility of scientific evidence is also intertwined with issues of access and equity within legal processes. Not all defendants have the resources to obtain neurological assessments or secure testimony from forensic neuroscience experts. If neuro-evidence is permitted as a basis for defence or sentence modification, disparities may emerge between well-resourced defendants and those lacking such access. As evidentiary standards increasingly rely on advanced technologies accessible only to certain parties, the principle of equality before the law becomes compromised. The integration of science into law, therefore, is not merely an epistemic concern but one that directly impacts procedural fairness.

Within the Indonesian legal framework, no normative instrument currently exists to manage this complexity. Judges are not equipped with evaluative tools to assess the validity or potential bias of scientific data. Nor is there a technical institution tasked with reviewing scientific methodologies prior to their use in court. This regulatory vacuum leaves the system open to data manipulation and the misuse of scientific authority by parties with vested interests. Institutional mechanisms are needed not only to determine whether scientific data is empirically valid but also whether it is legally admissible under the principles of justice, transparency, and accountability.

3.3. Procedural Gap: The Admissibility of Neuro-Evidence in Indonesian Courtrooms

Indonesia's criminal procedure system is structured around a conventional evidentiary model. Article 184 of the Criminal Procedure Code (KUHAP) recognises five forms of evidence: witness testimony, expert opinion, documents, indications, and statements of the accused. It does not explicitly acknowledge scientific evidence derived from technological instruments (Sucia & Deswari, 2024). Neuroscientific data produced through fMRI, EEG, or neuropsychological tests lacks autonomous legal standing and is instead filtered through expert testimony. This absence of recognition regarding the independent status of scientific data obscures the boundary between objective information and personal opinion. Consequently, questions arise concerning how the legal system screens, evaluates, and regulates the use of neuroscientific evidence in court.

In practice, judges tend to accept neuroscientific data insofar as it is delivered by experts deemed credible (O'Brien et al., 2022). However, there is no normative framework regulating how the validity of the methods, laboratory standards, or technical parameters of such data should be assessed. When neurobiological evidence is used to support defence arguments or justify sentence modification, no formal admissibility test ensures that the data meets an evidentiary standard comparable to other legally accepted forms of proof. In the absence of specific procedures, neuro-evidence becomes an extension of personal expert authority rather than an evidentiary entity grounded in its own verifiability.

Unlike more procedurally developed systems such as those in the United States or the United Kingdom, Indonesia has yet to establish a pre-trial admissibility hearing mechanism to evaluate scientific evidence (Wang, 2020). In models like *Daubert* or *Frye*, judges are granted the authority to assess in advance whether the scientific method used satisfies standards of acceptability within the relevant scientific community (Kwong, 2019). Such procedures are essential to prevent the introduction of unverifiable or

controversial methods into the courtroom. The lack of a similar mechanism in Indonesia means that evidentiary evaluation begins and ends in the courtroom, without prior filtration. This weakens institutional control over the entry of scientific data into legal processes.

A further issue lies in the documentation and transparency of data acquisition. Neuroscientific evidence such as fMRI not only requires expert interpretation but also depends on a data collection process governed by specific protocols. The quality of the results can be influenced by technical factors such as scanner resolution, scan duration, or the psychological condition of the subject during examination. Without standardised documentation procedures subject to independent review, the data presented by experts cannot be subjected to adversarial testing in court. This situation undermines the principle of contradiction in criminal procedure, which requires that evidence be open to challenge and counterargument.

The problem extends beyond data collection and evaluation into the domain of the defendant's rights. If neuro-evidence is used to assess levels of culpability or legal responsibility, defendants must have the right to access, understand, and respond to such data. However, not all defendants are equipped with legal representation capable of grasping the technical intricacies of neuroscience. This asymmetry creates the risk that complex scientific evidence may be used without commensurate comprehension or defence. The result is a weakening of the principle of equality of arms, producing an epistemic imbalance between prosecution and defence (Arslan, 2022).

In certain cases, the possibility arises that neuro-evidence may be selectively or manipulatively deployed. For example, the defence might invoke neurological data to construct a narrative of diminished responsibility, even when the data bears no direct causal link to the criminal behaviour in question (Vitacco et al., 2024). Without strict safeguards and adversarial checks, the potential for misuse of scientific data remains open. Such risks can lead to systemic bias, where technology becomes a tool of litigation strategy rather than a mechanism for advancing truth in legal proceedings.

Courts also face dilemmas regarding the probative value of neuroscientific evidence. Is such evidence sufficient to negate criminal responsibility, or does it merely serve as a mitigating factor in sentencing? In the absence of defined parameters, the answer to this question depends heavily on judicial discretion (Alimardani, 2023). This creates the danger of inconsistent rulings. Without normative guidance on the evidentiary function of neuro-data, judicial decisions risk becoming arbitrary and difficult to standardise. In the long term, this undermines legal certainty (Aven & Flage, 2022).

It is important to recognise that integrating scientific evidence into the legal system is not solely a matter of admissibility, but also of sustained management and evaluation. Without procedural frameworks, courts operate in a normative vacuum that erodes scientific accountability. A legal system that welcomes technological innovation must also establish mechanisms for methodological evaluation, laboratory audit, and expert registry structures that can be independently verified. Absent these safeguards, the judiciary risks falling behind the pace of scientific development, leaving legal decisions vulnerable to individual authority rather than grounded in data quality.

Reform of criminal procedure must therefore address both technical and procedural dimensions to enable responsible admission of scientific evidence. Merely revising the list of recognised evidentiary types is insufficient. Technical instruments must be developed to allow for systematic admissibility testing prior to courtroom use. Such mechanisms would not only protect the rights of defendants but also strengthen the legitimacy of judicial rulings. A legal system capable of adapting to scientific advancement is not one that accepts all innovations uncritically, but one that filters and integrates them with precision, transparency, and a commitment to justice.

4. CONCLUSION

As long as Indonesia's criminal justice system adheres to a normative assumption of free will and personal accountability, the integration of neurobiological approaches generates a substantial ontological conflict. The deterministic perspective offered by neurocriminology challenges this foundational assumption by presenting criminal behaviour as the product of empirically measurable neurological dysfunction. In the absence of a conceptual framework that bridges the divide between moral

responsibility and biological vulnerability, the legal system risks losing coherence in determining who may be held accountable, and on what grounds such accountability should be assigned.

Without normative and procedural mechanisms to regulate the admission, evaluation, and limitation of neuroscientific evidence, Indonesia's evidentiary system remains exposed to epistemic bias and disparities in access. The absence of legal instruments capable of assessing the methodological soundness of scientific data renders the courtroom dependent on the personal authority of experts, rather than on the verifiability of the data itself. This condition poses a serious threat to principles of justice, as it opens the door to manipulation and widens the gap between the advancement of scientific knowledge and the legal system's ability to manage it responsibly.

Ethical Approval

Ethical approval was not required for this study.

Informed Consent Statement

Informed consent was not obtained for this study.

Authors' Contributions

ZKK was responsible for conceptualizing the research framework and interpretation of the result. NFM assisted in literature review and supported the final editing process. All authors have reviewed and approved the final version of the manuscript.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Data Availability Statement

The data presented in this study are available on request from the corresponding author due to privacy reasons.

Funding

This research received no external funding.

Notes on Contributors

Zul Khaidir Kadir
https://orcid.org/0009-0001-7774-0790
Zul Khaidir Kadir is affiliated with Universitas Muslim Indonesia, where he is actively involved in teaching and research on criminal law. With a strong background in honor killing, neurocriminology, comparative criminal law, and criminal policy, his work explores the intersection of culture, neuroscience, and legal doctrine in shaping criminal responsibility. He is particularly committed to developing critical perspectives on criminal policy and advancing comparative approaches to reforming criminal law systems in Indonesia and beyond.

Nur Fadhilah Mappaselleng
Nur Fadhilah Mappaselleng is affiliated with Universitas Muslim Indonesia, where she focuses on teaching and research in criminal law. With expertise in customary criminal law, her work examines the legal and

cultural dimensions of *pembunuhan karena siri'* (honor-related killings) in South Sulawesi, exploring how adat norms intersect with state criminal law. She has more than 30 years of experience in academia and university teaching. She is particularly interested in developing legal frameworks that balance respect for local cultural values with the protection of human rights and the principles of modern criminal justice.

REFERENCES

Alimardani, A. (2023). An Empirical Study of the Use of Neuroscience in Sentencing in New South Wales, Australia. *Frontiers in Psychology*, *14*(1), 1–18. https://doi.org/10.3389/fpsyg.2023.1228354

Alsharif, A. H., Salleh, N. Z. M., & Baharun, R. (2021). Neuromarketing: The Popularity of the Brain-Imaging and Physiological Tools. *Neuroscience Research Notes*, *3*(5), 14–22. https://doi.org/10.31117/neuroscirn.v3i5.80

Arslan, O. (2022). Principle of Equality of Arms in Criminal Proceedings: A Systematic Review of Literature. *Ankara Barosu Dergisi*, *80*(4), 169–222. https://doi.org/10.30915/abd.1186643

Aven, T., & Flage, R. (2022). A Risk Science Perspective on Liability/Guilt and Uncertainty Judgments in Courts. *Risk Analysis*, *43*(1), 1525–1532. https://doi.org/10.1111/risa.14037

Beam, E., Potts, C., Poldrack, R. A., & Etkin, A. (2021). A Data-Driven Framework for Mapping Domains of Human Neurobiology. *Nature Neuroscience*, *24*(1), 1733–1744. https://doi.org/10.1038/s41593-021-00948-9

Darby, R. R. (2023). Network Localization of Antisocial Behavior in Neurological Patients: Evidence and Implications. *Handbook of Clinical Neurology*, *197*(1), 45–54. https://doi.org/10.1016/B978-0-12-821375-9.00009-8

Dias, B. de M., & Jacobsen, G. (2023). Scientific Evidence in Brazil: A Critical View Under the Daubert Standard. *Ponto de Vista Juridico*, *12*(1), 1–14. https://doi.org/10.33362/juridico.v12i1.3077

Dmytrrieva, M. (2021). The Peculiarities of Legal Certainty in Criminal Proceedings: Theoretical and Legal Aspects. *Baltic Journal of Legal and Social Sciences*, *3*(1), 59–67. https://doi.org/10.30525/2592-8813-2021-3-6

Jumantoro, T. R. P., & Firdausy, M. K. (2025). Transhumanistic Cybercrime Analysis Using a Posthuman Criminology Approach to Digital Identity Threats in Artificial Intelligence Era. *Priviet Social Sciences Journal*, *5*(9), 1–16. https://doi.org/10.55942/pssj.v5i9.558

Kadir, Z. K., & Mappaselleng, N. F. (2025). Reformasi Konsep Heat of Passion: Menuju Pembatasan Provokasi dalam Mengurangi Pertanggungjawaban Pidana Pembunuhan. *Justitiable-Jurnal Hukum*, *8*(1), 119–136. https://doi.org/10.56071/justitiable.v8i1.1293

Khalid, Z., Lee, R., & Wall, B. W. (2024). The Use of Neurobiological Evidence in Sentencing Mitigation. *Behavioral Sciences & the Law*, *42*(2), 65–78. https://doi.org/10.1002/bsl.2645

Kwong, L. (2019). Scientific Evidence Admissibility: Improving Judicial Proceedings to Decrease Erroneous Outcomes. *Themis: Research Journal of Justice Studies and Forensic Science*, *7*(5), 1–14. https://doi.org/DOI:10.31979/THEMIS.2019.0705

List, C. (2024). Mechanical Choices: A Compatibilist Libertarian Response. *Criminal Law and Philosophy*, *18*(1), 109–131. https://doi.org/10.1007/s11572-023-09671-x

Meynen, G. (2020). Neuroscience-Based Psychiatric Assessments of Criminal Responsibility: Beyond Self-Report? *Cambridge Quarterly of Healthcare Ethics*, *29*(3), 446–458. https://doi.org/10.1017/S0963180120000195

Mishra, P. (2024). Neuroscientific Paradigms and Their Implications for Jurisprudential Practice: A Comparative Analysis. *Athens Journal of Law*, *10*(3), 317–330. https://doi.org/10.30958/ajl.10-3-4

Nugroho, F. M., & Eskanugraha, A. P. (2023). Refleksi Asas Kemanfaatan: Mengilhami Asas Tiada Pidana Tanpa Kesalahan Tanpa Kemanfaatan. *Puskapsi*, *3*(1), 121–138. https://doi.org/10.19184/puskapsi.v3i1.40295

O'Brien, T. L., Hawskins, S. L., & Loesch, A. (2022). Scientific Disciplines and the Admissibility of Expert Evidence in Courts. *Socius: Sociological Research for a Dynamic World*, *8*(1), 1–14. https://doi.org/10.1177/23780231221108044

Ouerchefani, R., Ouerchefani, N., Rejeb, M. R. Ben, & Gall, D. Le. (2021). Impaired Perception of Unintentional Transgression of Social Norms after Prefrontal Cortex Damage: Relationship to Decision Making, Emotion Recognition, and Executive Functions. *Archives of Clinical Neuropsychology*, *37*(2), 249–273. https://doi.org/10.1093/arclin/acab078

Perkins, E. R., Bradford, D. E., Verona, E., Hamilton, R. H., & Joyner, K. J. (2023). The Intersection of Racism and Neuroscience Technology: A Cautionary Tale for the Criminal Legal System. *Policy Insight from the Behavioral and Brain Sciences*, *10*(2), 279–286. https://doi.org/10.1177/23727322231196299

Pernu, T. K., & Elzein, N. (2020). From Neuroscience to Law: Bridging the Gap. *Frontiers in Psychology*, *11*(1862), 1–23. https://doi.org/10.3389/fpsyg.2020.01862

Perricone, A. M., Sommers, A. B., & Ahn, W. (2022). The Effect of Neuroscientific Evidence on Sentencing Depends on How One Conceives of Reasons for Incarceration. *Plos One*, *17*(11), 1–17. https://doi.org/10.1371/journal.pone.0277067

Rao, K., Singh, R. R., Yadav, P. K., & Tripathi, S. K. (2023). Role of Scientific Evidence in the Judiciary System: A Systematic Review. *Indian Journal of Forensic Medicine & Toxicology*, *42*(2), 65–78. https://doi.org/0.37506/ijfmt.v17i4.19945

Recupero, P. R. (2022). Daubert Considerations in Forensic Evaluations by Telepsychiatry. *The Journal of the American Academy of Psychiatry and the Law*, *50*(4), 1–12. https://doi.org/10.29158/JAAPL.210161-21

Rosenzweig, G. (2022). Scientific Thinking About Legal Truth. *Frontiers in Psychology*, *13*(918282), 1–6. https://doi.org/10.3389/fpsyg.2022.918282

Serban, L. V. (2025). Neuroscience, Genetics, Education, and AI: Charting New Frontiers in Understanding Human Behavior and Criminal Responsibility. *Brain: Broad Research in Artificial Intelligence and Neuroscience*, *16*(1), 399–414. https://doi.org/10.70594/brain/16.S1/31

Setiadi, T., Rohaedi, E., Hosnah, A. U., & Kusnadi, N. (2021). Legal Sciences in the Perspective of Philosophy of Science. *International Journal of Multicultural and Multireligious Understanding*, *8*(7), 398–407. https://doi.org/10.18415/ijmmu.v8i7.2911

Smith, O. K. H. (2022). The Beyond a Reasonable Doubt Standard of Proof: Juror Understanding and Reform. *The International Journal of Evidence & Proof*, *26*(4), 291–308. https://doi.org/10.1177/13657127221114498

Sucia, Y., & Deswari, M. P. (2024). Bukti Elektronik dalam Sistem Peradilan: Memahami Peran dan Validitasnya. *Innovative: Journal of Social Science Research*, *4*(4), 13729–13741. https://doi.org/10.31004/innovative.v4i4.14698

Vitacco, M. J., Aguiar, R. J. N., Staats, P., & Coleman, S. (2024). Neuroscience and the Insanity Defense: Trying to Put a Round Peg in a Square Hole. *Forensic Science International: Mind and Law*, *5*(1), 1–5. https://doi.org/10.1016/j.fsiml.2024.100131

Wang, Z. (2020). The Fate of Evidence Law: Two Paths of Development. *The International Journal of Evidence & Proof*, *24*(1), 329–348. https://doi.org/10.1177/1365712720930797

Zhukovsky, P., Zamir, S. M., Meng, C., Dalley, J. W., & Ersche, K. D. (2020). Network Failures: When Incentives Trigger Impulsive Responses. *Wiley*, *41*(8), 2218–2228. https://doi.org/10.1002/hbm.24941