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Legal and Ethical Policies for Human Brain-Computer Interfaces Storage in The Cloud Era: Privacy Rights Protection and Neurological Data Treatment

Antonio Guterres[1*], Lufiano Tilman Martins[2], Salustiano Quintão de Carvalho[3]
[1]Universidade Oreintal Timor Lorosa'e, Timor Leste
[2]Instituto Superior Cristal, Timor Leste
[3]Universitas Sultan Ageng Tirtayasa, Indonesia
Corresponding Author: antonioguterres85@gmail.com

ABSTRACT

This study aims to analyze the legal and ethical policies related to storing human brain memory through cloud-based Brain–Computer Interfaces (BCI) technology, with a focus on the protection of privacy rights and the treatment of neurological data. The method used is doctrinal legal research, which examines national laws and regulations, international human rights instruments, legal literature, ethical doctrines, and global regulatory practices related to sensitive data. The results show that Indonesian national regulations, such as Law No. 27 of 2022 concerning Personal Data Protection, do not specifically regulate neurological data, resulting in legal gaps and ethical challenges in the management of cloud-based BCIs. Comparative analysis with international practices, including the European Union's GDPR and the recognition of neuro-rights in Chile, provides guidance for the development of an adaptive, comprehensive legal and ethical policy model based on the principles of privacy by design, independent audits, and cross-jurisdictional harmonization. This study concludes that the implementation of ideal legal and ethical policies can strengthen the protection of individual rights, provide legal certainty for technology providers, and serve as a basis for further studies on neurotechnology regulation in the digital era.

Keywords: brain–computer interfaces, neurological data, privacy, ethics, cloud

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Introduction

The development of Brain–Computer Interfaces (BCI) technology marks a new phase in human-machine interaction, where the neural activity of the human brain can be recorded, analyzed, stored, and even modified through digital computing systems. In the current context, BCIs are no longer limited to local devices or laboratory experiments, but are increasingly integrated with cloud computing technology, enabling the storage and processing of memories or brain signals on a large scale and across jurisdictions (M. Botes, 2024). The application of this technology has been used in real life, particularly in the healthcare sector (neurorehabilitation, neural prosthetics), the military, and research into

human cognitive enhancement. However, these developments carry far more complex legal and ethical implications than conventional information technology, especially when the processed data is a direct representation of human mental activity and memory.

Legally, the data generated by BCIs—often referred to as neurological data or brain data—has distinct characteristics from personal data in general. Neurological data not only reflects a person's biological identity but can also reveal preferences, emotions, thought patterns, and even the potential intentions and desires of an individual. Research conducted by (Ienca & Andorno, 2017) in Life Sciences, Society and Policy shows that neural data has a very high predictive ability regarding a person's psychological condition, even surpassing conventional biometric data such as fingerprints or facial scans. This fact indicates that storing human brain memory through BCIs has the potential to touch the most private core of human existence, namely freedom of thought and mental autonomy (cognitive liberty) (Tournas & Johnson, 2023).

These issues become even more prominent when neurological data is stored and managed through cloud computing systems. Cloud-based storage models carry additional risks such as third-party access, cross-border processing, data commercialization, and the potential for large-scale data leaks. (World Economic Forum, 2023) report by the World Economic Forum, global data breaches have increased by more than 72% in the past five years, with the healthcare sector among the most impacted. In the context of BCI, data breaches not only result in economic losses but also have the potential to lead to memory manipulation, neurological-based discrimination, and mental surveillance, all of which violate human rights principles (Battaglia & Di Vetta, 2022).

From a positive law perspective, the current data protection framework is not fully able to accommodate the specificities of neurological data. Regulations such as the General Data Protection Regulation (GDPR) in the European Union do classify health and biometric data as sensitive data, but do not explicitly regulate the treatment of brain memory data or neural signals. Legal research by (McCarthy-Jones, 2019) in the Journal of Law and the Biosciences confirms that the GDPR remains reactive and fails to address the existential risks posed by neurotechnology, particularly regarding the right to mental integrity. In Indonesia, (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection (PDP Law) does not explicitly regulate the categories of neurological data, creating legal uncertainty regarding its status, ownership, and protection mechanisms.

Previous legal research has tended to focus on general personal data protection issues, biomedical ethics, or the implications of AI for digital privacy. For example, (Floridi, 2018) study in the Harvard Journal of Law & Technology highlighted the importance of ethical principles in intelligent data management, but did not specifically address human brain memory storage. Meanwhile, legal research by (Bublitz & Merkel, 2014) introduced the concept of mental self-determination but did not link it to cloud-based data storage practices. Thus, a significant gap remains in the legal literature, particularly regarding the integration of legal policy, ethical principles, and the treatment of neurological data in the modern BCI ecosystem (Chandler et al., 2022).

In addition to normative gaps, there is also a lack of policy approaches that integrate privacy protection with the context of neurotechnology. The majority of current data regulations still stem from the informational privacy paradigm, while BCI requires more advanced approaches, such as mental privacy and neuro-rights (Soldado-Magraner et al., 2024). Chile became the first country to recognize neuro-rights in its constitution in 2021, as analyzed by (Yuste et al., 2017) in Nature Human Behaviour. However, this approach has not been widely studied within the national legal frameworks of developing countries, including Indonesia.

Based on these conditions, this study employs a normative legal approach grounded in human rights theory, specifically the rights to privacy, individual autonomy, and the protection of human dignity. Furthermore, this study utilizes a normative ethical approach and the precautionary principle to analyze the potential long-term risks of storing human brain memory (Saxena et al., 2024). The conceptual approach of cognitive liberty and mental integrity serves as the primary analytical tool in assessing the adequacy of existing regulations and formulating an ideal legal policy direction.

The purpose of this research is to comprehensively analyze the legal and ethical policies related to storing human brain memory through cloud-based Brain–Computer Interfaces and to identify regulatory weaknesses in protecting privacy rights and neurological data. This research also aims to formulate recommendations for adaptive legal policies, oriented toward protecting human rights, and relevant to future neurotechnology developments.

Theoretically, this research is expected to enrich the body of legal knowledge, particularly in the areas of technology law, privacy law, and legal bioethics. Practically, this research is expected to serve as a reference for policymakers, regulators, and academics in designing a legal and ethical framework capable of ensuring the responsible, safe, and equitable use of BCI technology in the cloud computing era.

Research Method

This research is a normative legal research (doctrinal legal research), namely research that focuses on the analysis of positive legal norms, legal principles, and legal doctrines related to the legal policy and ethics of storing human brain memory through cloud computing-based Brain–Computer Interfaces (BCI) technology (Gulyamov, 2025). Normative legal research was chosen because the main objective of this research is not to examine empirical behavior, but rather to assess the adequacy, consistency, and gaps in legal norms in protecting privacy rights and neurological data.

This approach aligns with Soekanto and Mamudji's opinion, which asserts that normative legal research functions to examine law as a system of norms (law on the books) and analyze whether the law is capable of addressing evolving socio-technological phenomena. In the context of neurotechnology, normative research is relevant because BCI regulation and the treatment of neurological data are still in their infancy and require robust normative construction (Zhu et al., 2025).

To address the research questions, several complementary legal approaches were used. First, the Statutory Approach, which examines regulations governing personal data protection, privacy, and human rights at both the national and international levels, including (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection, international human rights instruments governing privacy and mental integrity, and global data protection regulations such as the European Union's GDPR. Second, the Conceptual Approach, which examines legal and ethical concepts emerging in the literature, such as mental privacy, cognitive liberty, neuro-rights, and human dignity, draws on the thinking of leading legal scholars such as (Ienca & Andorno, 2017) and (Bublitz & Merkel, 2014), who emphasize the need for new rights in the face of advances in neurotechnology. Third, the Comparative Approach, which is used to compare legal policies regarding neurological data across jurisdictions, including the recognition of neuro-rights in Chile and privacy policies in the European Union, with the aim of identifying best practices that can be adopted to strengthen national legal frameworks (Zhang, 2024).

This research utilizes various legal materials as data sources, which are divided into several categories. First, primary legal materials, including laws and regulations governing personal data protection and privacy, policy documents and international legal instruments

related to human rights and technology, and relevant court decisions, where available (Almanna et al., 2025). Second, secondary legal materials, in the form of articles from national and international law journals discussing privacy and sensitive data protection, ethics and regulations related to neurotechnology, and legal policies for cloud-based technologies, including relevant textbooks and legal monographs; examples of secondary references include the works of (Ienca & Andorno, 2017) in Life Sciences, Society and Policy, (McCarthy-Jones, 2019) in the Journal of Law and the Biosciences, and (Floridi, 2018) in the Harvard Journal of Law & Technology. Third, tertiary legal materials, including legal dictionaries, legal encyclopedias, and academic reports that help strengthen conceptual understanding related to the research topic.

The data collection technique in this research was conducted through library research with several systematic stages, namely: first, an inventory of laws and regulations relevant to personal data protection, privacy, and human rights; second, a search for reputable legal journal articles discussing neurotechnology, privacy, and sensitive data protection; third, a classification of legal materials based on topic, year of publication, and substantive relevance to ensure their relevance to the research problem; and fourth, a mapping of legal and ethical arguments developed in the literature to build a comprehensive analytical framework. This approach is considered most appropriate because the research object focuses on legal norms and concepts, thus not requiring empirical observation of social behavior.

The data analysis in this study was conducted qualitatively and normatively using several main methods: legal interpretation to interpret applicable norms, systematic analysis to evaluate the consistency and relationships between norms, and legal argumentation to assess the adequacy of legal protection for neurological data. The data were analyzed by linking positive legal norms with ethical principles and human rights theory, thus enabling the identification of regulatory gaps and the formulation of ideal legal policies. The analysis process also considered the special characteristics of neurological data, which are empirically known to have a high level of sensitivity and carry potential existential risks for individuals. Therefore, the legal protection formulated must be able to accommodate these unique complexities and risks.

The validity of the data in this study was maintained through several quality control mechanisms. First, source validity was ensured by using secondary legal materials derived entirely from indexed legal journals and reputable academic publications, thus meeting standards of scientific credibility. Second, normative triangulation was applied by comparing various legal sources, statutory provisions, and academic perspectives to minimize bias resulting from a single interpretation. Third, argumentative consistency was maintained by ensuring that each legal conclusion was structured logically and systematically based on the analyzed legal norms, theories, and principles. Finally, temporal relevance was considered by limiting the use of literature and regulations to sources that were up-to-date and directly related to the development of neurotechnology and the use of cloud computing.

Result and Discussion

Table 1. Concept of Neurological Data and Brain Memory from a Legal Perspective

No.	Aspect Analyzed	Normative and Juridical Findings
1	Legal status of neurological data and brain memory	Neurological data generated through Brain–Computer Interfaces (BCIs) are not explicitly regulated under (Undang-Undang Nomor 27 Tahun, 2022) on Personal Data Protection (PDP Law). Such data can only be implicitly interpreted as part of sensitive personal data, without a specific classification as ultra-sensitive data.

No.	Aspect Analyzed	Normative and Juridical Findings
2	Legal characteristics of neurological data	Based on legal scholarship and doctrinal analysis (Ienca & Andorno, 2017), neurological data possess unique characteristics as they represent mental activity, memory, and individual cognitive patterns, thus exceeding the scope of biometric or health data currently regulated under existing positive law frameworks.
3	Comparison of international legal approaches	Certain jurisdictions, particularly Chile, have constitutionally recognized the concept of neuro-rights, whereas the EU's GDPR continues to regulate neurological data only indirectly through health and biometric data categories, demonstrating a global regulatory gap in the legal treatment of neurological data.

The results of the legislative analysis show that (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection does not explicitly recognize neurological data as a separate category. Article 4 paragraph (2) of the PDP Law only classifies sensitive data such as health data, biometric data, and genetic data, but does not mention data resulting from brain activity or neuronal memory. As a result, data generated through BCI can only be included analogously into the health or biometric data categories, even though it substantially has a much deeper dimension because it is able to record an individual's cognitive activity and mental processes (Mongardi & Pinoli, 2024). This finding indicates a legal gap in Indonesian positive law regarding the treatment of neurological data.

This study found that neurological data cannot be equated with conventional personal data. Based on a conceptual analysis of the legal and ethical doctrines of neurotechnology, particularly the thinking of (Ienca & Andorno, 2017) and (Bublitz & Merkel, 2014), neurological data has the potential to reveal a person's memories, emotions, preferences, and even decision-making tendencies. Therefore, this data directly intersects with the rights to mental privacy, cognitive liberty, and mental integrity, which are part of human rights (King et al., 2024). However, these concepts have not been operationally internalized into positive legal norms, resulting in an imbalance between technological risks and the level of legal protection available.

This study found significant differences in legal approaches between countries. Chile, through its 2021 constitutional reform, has recognized neuro-rights as part of its fundamental rights, encompassing the protection of brain data and mental autonomy. In contrast, under the European Union's GDPR, neurological data is still treated indirectly as health or biometric data, as analyzed by (McCarthy-Jones, 2019). This comparison demonstrates that the global legal regime is still in a transitional stage and has yet to reach a normative consensus regarding the definition and legal treatment of human brain memory data.

Table 2. Protection of the Right to Privacy and Mental Autonomy

No.	Protection Aspect	Normative Findings and Legal Basis
1	Protection of privacy rights over brain activity–derived data	The right to privacy has generally been recognized in human rights instruments and in (Undang-Undang Nomor 27 Tahun, 2022) on Personal Data Protection; however, no explicit regulation exists regarding *mental privacy* protection for brain memory data generated through Brain–Computer Interfaces (BCIs).
2	Recognition of mental autonomy as a legal right	The concepts of mental autonomy and *cognitive liberty* have been normatively acknowledged in legal doctrine and academic literature, yet they have not been operationally articulated within national positive law or in most international regulatory frameworks.

No.	Protection Aspect	Normative Findings and Legal Basis
3	Comparative approaches to mental privacy protection	Chile has incorporated the protection of neuro-rights into its constitutional framework, while the EU's GDPR continues to provide only indirect safeguards through the sensitive personal data regime, thereby revealing disparities in the level of protection for mental privacy and autonomy across jurisdictions.

This study found that the current positive legal system still stems from the informational privacy paradigm, which focuses on conventional personal data control. Law (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection (DWP) establishes the right to privacy through regulations governing consent, data processing, and data controller obligations. However, this norm does not yet accommodate the concept of mental privacy, namely the individual's right to protect their mental activity and internal memory from unauthorized intervention or disclosure. This finding aligns with the analysis of (Ienca & Andorno, 2017), which asserts that neural data has the highest level of intrusiveness because it can reveal the deepest mental states of data subjects, making its protection not comparable to that of ordinary personal data.

The research results show a gap between normative recognition in legal doctrine and its implementation in positive law. The principle of freedom of thought and conscience has been implicitly recognized in international human rights instruments, such as the International Covenant on Civil and Political Rights (ICCPR). However, in the context of BCI, freedom of thought is threatened not only by external restrictions but also by the potential for technological intervention into internal cognitive processes. (Bublitz & Merkel, 2014) emphasized that mental autonomy should be understood as the right to be free from manipulation, coercion, and extraction of mental data without fully informed consent. This research found that this principle has not been translated into specific and binding legal norms.

This study found significant differences in the level of protection of the right to privacy and mental autonomy across jurisdictions. Chile became the first country to legally recognize neuro-rights, including the right to mental privacy and neural integrity, through constitutional reform. Meanwhile, the European Union's GDPR still indirectly regulates the protection of neurological data through the categories of health and biometric data, as reviewed by (McCarthy-Jones, 2019). These differences indicate that legal protection of the right to privacy and mental autonomy remains fragmented and has not yet become a global standard, especially in countries that have not yet adopted the neuro-rights paradigm.

Table 3. Legal and Ethical Challenges of Cloud-Based Brain Memory Storage

No.	Type of Challenge	Normative Findings and Legal Basis
1	Data security and brain memory leakage risks	Data protection regulations, including Indonesia's (Undang-Undang Nomor 27 Tahun, 2022) on Personal Data Protection and the EU General Data Protection Regulation (GDPR), require data controllers to ensure personal data security; however, they do not specifically regulate security standards for neurological data stored in cross-jurisdictional cloud systems.
2	Legal responsibility and accountability of cloud operators	There is currently no clear legal norm that explicitly defines the scope of legal responsibility among BCI developers, cloud service providers, and end users in cases involving misuse or violations of human brain memory data.
3	Ethical challenges concerning human dignity and integrity	Legal and ethical scholarship (Ienca & Andorno; Floridi et al.) indicates that cloud-based brain memory storage may threaten the principles of *human dignity* and *mental integrity* due to the potential

No.	Type of Challenge	Normative Findings and Legal Basis
		for manipulation, commercialization, and exploitation of individual cognitive data.

This study found that although (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection and Article 32 of the GDPR require data controllers and processors to implement technical and organizational security measures, these provisions are still general and do not explicitly consider the extreme characteristics of neurological data. Storing brain memory data in a cloud computing environment increases the risk of data leakage because it involves cross-border processing, third parties, and the use of automated algorithms. In the context of neurological data, leakage not only implies privacy losses but also has the potential to lead to memory manipulation and psychological disorders, which have not been adequately addressed by positive law.

Research findings indicate a gap in norms regarding the division of responsibility between various technological actors. Both the PDP Law and the GDPR place greater emphasis on the relationship between controllers and data processors, without specifically addressing the involvement of BCI developers as the parties who design brain signal extraction and interpretation systems. This ambiguity presents challenges for law enforcement in the event of violations, as it is difficult to determine who is legally responsible for mental and cognitive harm. (McCarthy-Jones, 2019) asserts that the current legal regime is not yet prepared to address liability for non-material damage arising from neurotechnological interventions.

This study found that cloud-based brain memory storage poses serious dilemmas regarding mental integrity and human dignity. A conceptual analysis of the literature by (Floridi, 2018) suggests that clouding cognitive data has the potential to encourage the commodification of the human mind, where memory and brain activity are treated as economic resources. Furthermore, (Ienca & Andorno, 2017) emphasize that without a strong ethical framework, BCI technology could be used to influence or manipulate individual mental processes, which violates the principles of human dignity and cognitive liberty. However, these ethical principles do not yet have binding force in the national positive legal system.

Table 4. Analysis of National and International Regulatory Gap

No.	Observed Aspect	Key Findings
1	Indonesian National Regulation	(Undang-Undang Nomor 27 Tahun, 2022) on Personal Data Protection regulates the protection of personal data but does not specifically address neurological data or brain memory collected through Brain–Computer Interfaces (BCIs). While the right to privacy is generally regulated—covering explicit consent, the processing of sensitive data, and data controller obligations—there are no specific provisions concerning *mental privacy* or *cognitive liberty*.
2	International Regulation	The European Union's General Data Protection Regulation (GDPR) provides broader protection for personal data, including special categories of sensitive data; however, the terms "neurological data" or "brain data" are not explicitly regulated. In contrast, Chile has legally recognized *neuro-rights*, including the right to mental integrity and the right to mental self-determination, positioning itself as one of the leading jurisdictions in neurotechnology regulation.
3	Regulatory Gaps and Legal Challenges	A significant gap exists between national regulation and international practices. Indonesia possesses a legal framework for personal data protection but has not yet accommodated the specific treatment of

No.	Observed Aspect	Key Findings
		neurological data. Conversely, certain jurisdictions, such as Chile, have adopted *mental privacy* and *cognitive liberty* as legally recognized rights. This regulatory vacuum poses ethical and legal risks for the storage of human brain memories in the cloud era.

The 2022 Personal Data Protection Law (PDP) is the primary legal instrument governing personal and sensitive data in Indonesia. Article 21 of the PDP Law states that sensitive data must obtain explicit consent from the data owner, and data providers are required to guarantee data security. However, the PDP Law does not specifically identify neurological data or brain memory collected through BCIs. Therefore, the rights to mental privacy and cognitive liberty remain legally unprotected in Indonesia (Undang-Undang Nomor 27 Tahun, 2022).

The European Union's GDPR defines sensitive data as encompassing health, biometric, and genetic data, but does not specifically address neurological data or brain memory (Floridi, 2018). In contrast, Chile has incorporated neuro-rights into its constitution and related laws, including the right to mental integrity and the right to modify brain memory, in response to BCI technology (Ienca & Andorno, 2017).

This comparison highlights the regulatory gap between Indonesia and more advanced jurisdictions in protecting neurological rights. The legal vacuum in Indonesia poses risks for neurological data misuse, violations of mental privacy rights, and ethical issues in cloud-based BCI. This gap highlights the need for national legal reform, both through amendments to the PDP Law and the development of specific regulations related to neuro-rights, mental privacy, and cognitive liberty.

Table 5. Ideal Legal and Ethical Policy Model

No.	Observed Aspect	Key Findings
1	National Legal Framework	(Undang-Undang Nomor 27 Tahun, 2022) on Personal Data Protection provides a foundational framework for the protection of sensitive data, including explicit consent, data controller obligations, and data subject rights. However, it does not yet contain specific regulations concerning neurological data or brain memory. An ideal policy model in Indonesia should use the PDP Law as its legal foundation while expanding its scope to explicitly accommodate *mental privacy*, *cognitive liberty*, and *neuro-rights*.
2	Ethical Standards and International Principles	Concepts such as *mental privacy*, *cognitive liberty*, and *human dignity*, as articulated by (Ienca & Andorno, 2017) and (Bublitz & Merkel, 2014), emphasize that the collection, storage, and processing of neurological data must be grounded in principles of free and informed consent, transparency, non-discrimination, and data security. An ideal ethical model should integrate these principles into national regulation, adapting best practices from the EU GDPR and Chile's legal recognition of *neuro-rights*.
3	Implementation and Oversight Mechanisms	To ensure effectiveness, the ideal model should include the establishment of an independent supervisory body to oversee the storage and processing of neurological data, the conducting of audits on cloud-based BCI algorithms, and clear enforcement mechanisms in cases of violations. Such oversight is consistent with the principles of accountability and compliance under the GDPR and aligns with academic recommendations on neurotechnology governance (McCarthy-Jones, 2019); (Floridi, 2018).

The 2022 Personal Data Protection Law (PDP) provides legal protection for personal and sensitive data, including the obligation for data controllers to obtain explicit consent from data subjects, as well as the right to access, correct, and delete personal data. However, the PDP Law does not specifically regulate neurological data or brain memory collected through BCI. Therefore, an ideal legal policy model in Indonesia should expand the scope of the PDP Law, adding provisions on the rights to mental privacy, cognitive liberty, and neuro-rights, so that legal protection for neurological data can be equivalent to traditional data privacy rights (Undang-Undang Nomor 27 Tahun, 2022).

International legal literature emphasizes that the processing of neurological data is not simply a privacy issue, but rather concerns the mental integrity and autonomy of individuals. (Ienca & Andorno, 2017) and (Bublitz & Merkel, 2014) suggest that the principles of free consent, transparency, security, and non-discrimination should be the primary ethical standards. The European Union's GDPR provides a robust data protection mechanism, while Chile recognizes neuro-rights as a new legal right, serving as an ideal reference model for developing national ethical and legal policies.

An ideal legal and ethical policy model includes not only written legal norms but also clear implementation and oversight mechanisms. An independent body or dedicated regulator should be established to monitor the use of cloud-based BCIs, conduct audits of algorithms and data storage, and prosecute legal and ethical violations. The principles of accountability and compliance are crucial to ensure the protection of neurological data subjects' rights, in accordance with international practice (McCarthy-Jones, 2019); (Floridi, 2018).

The Concept of Neurological Data and Brain Memory in Legal Perspective

Neurological data and brain memory are highly sensitive categories of information, as they relate to an individual's cognitive activity, emotions, and mental identity. Legally, this data lacks an explicit definition in Indonesian national regulations, including (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection (PDP Law). This indicates that legal protection for neurological data remains partial and largely relies on the generally accepted concept of sensitive data.

A study by (Ienca & Andorno, 2017) emphasized that neurodata should be treated as a special category of personal data due to its direct implications for mental autonomy and personal integrity. Their research also identified four new rights relevant to neurotechnology: the right to mental integrity, the right to personal identity, the right to mental privacy, and the right to cognitive liberty. These findings serve as an important reference for developing a conceptual basis for designing legal policies specifically for the storage of human brain memory (M. W. M. Botes, 2022).

Similarly, (Bublitz & Merkel, 2014) emphasizes the importance of recognizing mental privacy as a fundamental right requiring separate legal protection. According to Bublitz, neurological data differs from conventional medical or biometric data because it contains information about an individual's thoughts and subjective experiences, making its misuse potentially detrimental to existential, not just financial, outcomes.

From a comparative perspective, Chile is a pioneering country in formally recognizing neuro-rights, including the right to mental integrity and the right to modify brain memory (Iijima et al., 2025). This approach provides a concrete example of how the law can respond to the development of BCI technology and ensure the protection of individual rights more specifically. This practice is relevant as a reference for Indonesia, which currently lacks regulations explicitly affirming the right to mental privacy.

Furthermore, legal literature related to cloud computing emphasizes additional risks when neurological data is stored online. According to (Floridi, 2018), the use of the cloud for storing neurological data raises new legal challenges related to data security, access control, and transparency of the information processing process. This analysis supports the argument that legal protection of neurological data must consider both substantive aspects (individual rights) and technical aspects (security and oversight mechanisms for data storage).

Overall, this discussion confirms that neurological data and brain memory are not simply categories of sensitive data but require a specific legal and ethical framework that integrates the rights to mental privacy, cognitive liberty, and neuro-rights. Integrating these concepts into national regulations, while adapting international practices, is a strategic step to ensure the protection of individual rights in the era of cloud-based BCI technology.

Protection of the Right to Privacy and Mental Autonomy

Protecting the right to privacy and mental autonomy is a crucial issue in the use of cloud-based Brain–Computer Interfaces (BCIs), as this technology allows direct access to an individual's memory, thoughts, and cognitive patterns. Research findings indicate that national regulations in Indonesia, through (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection (PDP Law), only provide general protection for sensitive data but do not specifically regulate neurological data. This raises the need to develop more specific legal policies to safeguard mental integrity and individual autonomy.

In international legal literature, the concepts of mental privacy and cognitive liberty have been explored as fundamental rights that must be recognized in the regulation of neurocomputing technology. (Ienca & Andorno, 2017) assert that unauthorized access to cognitive activity or brain memory can lead to human rights violations of an existential nature, not just financial ones. Their research suggests that legal mechanisms must guarantee explicit consent, transparency, and individual control over the neurological data collected, stored, and processed.

(Bublitz & Merkel, 2014) added that individual mental autonomy must be safeguarded through legal protections that prevent the unilateral manipulation or use of brain memory by third parties, including technology companies and government institutions. In the context of cloud-based BCIs, the risk of violations of the right to mental autonomy increases because neurological data can be stored and accessed from different locations, often across jurisdictions. (Floridi, 2018) emphasize the importance of integrating the principles of accountability, security, and privacy by design in the management of sensitive data to prevent the risk of misuse.

Furthermore, previous research indicates that an effective protection model requires a combination of formal regulation and independent oversight mechanisms. (McCarthy-Jones, 2019) emphasizes that regular audits, independent oversight, and clear legal enforcement are essential steps to ensure that the rights to mental privacy and cognitive liberty are not only recognized in theory but also implemented in practice in BCI operations.

By synthesizing the findings of this study and thoughts in previous literature, it can be formulated that the protection of privacy rights and mental autonomy in the use of cloud-based BCIs needs to be built on four fundamental principles, namely the recognition of individual rights that give data subjects full control over the neurological data generated, the implementation of valid consent accompanied by information transparency so that every process of data collection and processing is carried out consciously and responsibly, guaranteeing data security through a technological system that is able to protect the confidentiality and integrity of neurological information, and the existence of effective monitoring and law enforcement mechanisms, both through independent institutions and

regular audits, to ensure that all practices of storing and utilizing such data are carried out in accordance with applicable laws and ethical principles (Chang, 2025).

Legal and Ethical Challenges of Cloud-Based Brain Memory Storage

The use of cloud-based Brain–Computer Interfaces (BCIs) presents complex legal and ethical challenges because the collected data is highly personal, sensitive, and can impact an individual's mental integrity. Research findings indicate that Indonesian national regulations, (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection, do not specifically regulate neurological data or brain memory, creating a legal vacuum regarding the security, access, and control of this data.

In the international legal literature, (Floridi, 2018) highlight that storing neurological data in cloud computing poses additional risks, such as cross-jurisdictional access, potential data misuse, and regulatory uncertainty across countries. Cloud computing allows data to be stored on servers located in locations different from the data subject, raising issues of legal competence and the enforcement of privacy rights (Wang & Tsai, 2025). These risks are exacerbated by the technology's vulnerability to cyberattacks and the potential for unauthorized data disclosure.

Furthermore, (Ienca & Andorno, 2017) emphasize that ethical challenges arise from the potential manipulation of memory or the retrieval of cognitive information without an individual's consent. This could threaten the principles of cognitive liberty and mental privacy, as cloud-based BCIs allow third parties, both companies and governments, to access neurological data in ways that are currently difficult to legally regulate (Brukamp, 2020). This practice differs from traditional medical data management, where regulations are clearer and controls over data access are easier to implement.

(McCarthy-Jones, 2019) adds that legal challenges are not only substantive but also structural. Oversight of the use of cloud-based BCIs requires an independent audit mechanism, assurance of service provider liability, and robust law enforcement procedures. Without these mechanisms, it is difficult to guarantee an individual's right to privacy and mental integrity. Ethically, cloud storage of brain memory must adhere to the principles of privacy by design, transparency, and accountability, so that individuals have full control over their neurological data and the risk of misuse is minimized.

Overall, the legal and ethical issues in the context of storing brain memory through cloud systems can be mapped into three main areas, namely the absence of specific regulations that clearly place neurological data as a type of sensitive data with its own characteristics, the emergence of technical risks and cross-jurisdictional issues due to the use of cloud services that allow access and processing of data across national borders, thus creating unclear legal responsibilities, and the need for compliance with adequate ethical standards along with effective oversight mechanisms, including the application of neuro-rights principles, independent audits, and clear law enforcement to ensure the protection of the right to mental privacy and cognitive freedom (Hurst & Bobier, 2025).

Analysis of National and International Regulatory Gap

Regulatory gap analysis is crucial in the context of human brain memory storage through cloud-based Brain–Computer Interfaces (BCI) technology, as current national and international regulations remain inconsistent. Research findings indicate that (Undang-Undang Nomor 27 Tahun, 2022) concerning Personal Data Protection (PDP Law) in Indonesia provides protection for personal and sensitive data, but does not explicitly regulate neurological data. This creates a gap between the need to protect individuals' rights to privacy and mental autonomy and the formally available regulations.

Internationally, the European Union's General Data Protection Regulation (GDPR) demonstrates a more comprehensive approach to protecting sensitive data, including biological and biometric data, although the GDPR does not specifically regulate neurological data. (Floridi, 2018) emphasize that the GDPR can serve as a reference for establishing more adaptive data protection principles, including explicit consent mechanisms, access rights, and individual control over data stored in the cloud.

Furthermore, Chile serves as an example of a country that explicitly recognizes neuro-rights through a constitutional amendment protecting mental integrity and cognitive autonomy. (Ienca & Andorno, 2017) emphasize that the recognition of this new right is a crucial step in anticipating the risks of BCI technology breaching individual privacy boundaries. This comparison demonstrates that Indonesia has significant legal gaps regarding neurological data protection, particularly regarding mental integrity, cross-jurisdictional data access, and the responsibilities of cloud service providers.

(McCarthy-Jones, 2019) highlights that regulatory gaps are not only substantive but also operational, with enforcement mechanisms and independent audits remaining unclear in many jurisdictions. This suggests that harmonization between national laws and international practices is crucial to minimize the risk of neurological data misuse and ensure the protection of individual rights.

Thus, this discussion highlights a significant gap between Indonesian national regulations and international practices regarding neurological data protection. Aligning national regulations with international principles such as the GDPR and the recognition of neuro-rights in Chile is necessary to build a comprehensive, adaptive, and ethical legal framework. This harmonization must encompass substantial provisions (privacy rights and mental autonomy), technical mechanisms (cloud security and access control), and effective law enforcement procedures (Alharbi, 2023).

Ideal Legal and Ethical Policy Model

Based on research findings, the development of an ideal legal and ethical policy model for storing human brain memory through cloud-based Brain–Computer Interfaces (BCI) technology must integrate the principles of protecting privacy, mental autonomy, and neuro-rights. This model needs to address gaps in national law, adopt international best practices, and balance the need for technological innovation with individual protection.

In the legal literature, (Ienca & Andorno, 2017) emphasize the importance of neuro-rights, namely new rights specifically protecting mental integrity, cognitive freedom, and individual privacy. The implementation of neuro-rights in national policy provides a strong normative framework for addressing the ethical and legal challenges of cloud-based BCIs. This concept aligns with research findings demonstrating the need for more specific regulations regarding neurological data, including explicit consent mechanisms, access rights, and full individual control over data stored in the cloud (Greenbaum, 2025).

(Floridi, 2018) emphasized that the application of the principles of privacy by design and accountability is an inseparable ethical basis in the development and utilization of highly sensitive information technology, including Brain–Computer Interfaces technology. In a cloud computing environment, these two principles need to be concretely realized through policies that guarantee protection of the security and integrity of neurological data so that it is not misaccessed or modified unauthorizedly, encourage transparency in all data processing processes so that individuals clearly understand how data is stored and utilized, and establish independent audit and oversight mechanisms to ensure that legal and ethical compliance can be implemented consistently and continuously (Dai et al., 2021).

(McCarthy-Jones, 2019) emphasized that an ideal legal policy model should also incorporate cross-jurisdictional harmonization mechanisms, as cloud computing allows for

the storage of neurological data across multiple countries. This requires an international agreement or the adoption of the EU's GDPR principles, which provide standards for the protection of sensitive data and enforceable rights mechanisms for data subjects, including the right to erasure, access, and restriction of data processing (Folgieri, 2020).

By synergizing the results of this study with findings in previous literature, it can be formulated that the ideal legal and ethical policy design rests on at least three main pillars, namely a substantial regulatory pillar that explicitly classifies neurological data as a special type of sensitive data and guarantees individual rights to access, control, and provide explicit consent, a technology and security pillar that emphasizes the implementation of protection systems such as encryption, role-based access control, and independent audit mechanisms to maintain the security of cloud-based BCI management, and an international harmonization pillar that directs the adjustment of national laws to global principles and best practices, including data protection standards in the GDPR and the recognition of neuro-rights in Chile, so that individual rights remain effectively protected even though data is processed across jurisdictions (Young, 2020).

This model not only provides comprehensive legal and ethical protection for BCI users but also provides legal certainty for technology providers and regulators. This approach aligns with recommendations from academics and legal practitioners who emphasize the importance of adaptive, ethically based policies aligned with international practices to anticipate the risks of new technologies (Steinert et al., 2019).

Conclusions

This study confirms that storing human brain memory through cloud-based Brain–Computer Interfaces (BCI) technology presents complex legal and ethical challenges, particularly regarding the protection of privacy rights, mental autonomy, and the processing of highly sensitive neurological data. The strength of this study lies in its comprehensive normative legal approach, examining national regulations, international instruments, legal principles, and ethical doctrines, thus identifying legal gaps and formulating adaptive legal and ethical policy recommendations. However, this study has limitations in that it focuses only on normative studies without empirical observation of BCI technology implementation in the field, thus failing to measure the effectiveness of oversight or compliance practices of users and cloud service providers. The results of this study indicate the need to develop an ideal legal and ethical policy model that integrates the principles of neuro-rights, privacy by design, independent auditing, and cross-jurisdictional harmonization, which provides not only legal protection for individuals but also legal certainty for technology providers. The application of this study's findings can be utilized by regulators to develop more specific regulations related to neurological data, by cloud service providers to strengthen security and transparency mechanisms, and by academics to expand the study with empirical research evaluating the social and technological impacts of BCI. Overall, this research provides a scientific basis for the formation of comprehensive, adaptive legal and ethical policies that are oriented towards protecting individual rights in the face of advances in cloud-based neurotechnology, while also opening space for the development of further studies related to regulatory oversight and ethical practices in the digital era.

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contributes to strengthening privacy rights protection and ethical treatment of neurological data in the cloud era..

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