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REVIEW ARTICLE

The application of neuroscience to law and new legal dilemmas: A systematic review

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ABSTRACT

All our moral and legal judgments are centered on our decision making and actions, the same decisions are driven by our brain, so would it be logical to understand the functioning of the brain, through manipulation with sophisticated methods, in order to find answers in a courtroom? Research scholars point out that if it is possible to decipher the neural code of a person, this would allow understanding the functioning of brain activity in various ways, coupled with this such methods when applied to the field of law could radically change the traditional judicial system. However, for many, this method could be considered as an aberration to the fundamental rights of the person. Therefore, the objective of this research is to analyze and interpret the application of neuroscience to law, and its legal dilemmas. In this sense, a qualitative approach was considered for the elaboration of this research. The methodology used was based on the consultation of six databases: Scopus, Web of Science, IEEE, EBSCOhost and Springer. The main findings obtained indicate that the method of neuroscience applied to law through algorithms can trigger and decipher the neural code of the offender, however, it is concluded that there is a large part of researchers who question this method because of its controversial interaction with the human brain.

Keywords: neurolaw; human rights; neuroscience; free will

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1. Introduction

In recent years, with the dizzying progress of technology and science, new methods have appeared to decipher and predict the neural code of people, this method was called neuroscience, this same technique is based on the interaction of algorithms with our nervous system to monitor or modulate neural activity, also several countries such as Chile, United States and Italy tried to apply this method to legal issues, such as criminal law, civil law to the same began to be known by the name of neurolaw. Now, according to a naturalistic and scientific projection of the world, the idea that the human mind, our decision making and our behaviors, can also be controlled through sophisticated methods aided by science, thus is subsumed in the idea of neuroscience, according to Stieglitz[1], the interaction between neuroscience and law has been characterized mainly by a practical dimension. What has happened is that neuroscientific theories and technologies have been used as evidence in trials, especially in criminal trials, and particularly in the context of the expert evaluation of insanity, also with mind control could revolutionize the civil criminal justice system so we could control the moral and legal judgments of individuals, but the idea arises that the methods used for mind control are a damage to the rights of the person mainly to his free will.

Continuing with the same line of argument, the great scholars in neurotechnology research were José MR Delgado (1915–2011) and Elliot S. Valenstein (born in 1923). Both researchers contributed significantly to the scientific field, it is from their findings that the discussion on the application of neuroscience to law was born, however, since 1990 many academic events have been developed such as: conferences, seminars and workshops promoted by prestigious universities in topics of neurolaw, in addition to this, the research developed grew notably in 2004, scientists and law scholars began to debate the application of neuroscience to the legal field, likewise, to date there are few authors who have carried out a literature review on this.

In that sense, this research will develop extensive knowledge about the expansion of neurolaw in criminal matters and its techniques to find evidentiary value in the courts, and will also expose the violation that neurolaw brings with it in the areas of human rights and fundamental rights, as well as the impact on free will, finally the most important results and findings will be highlighted.

2. Methodology

For the proper development of this research, we proceeded to conduct a systematic literature review to identify the various research and studies that gave a descriptive and quantitative approach to neurolaw, also for obtaining scientific studies were taken as reference, six electronic online databases, which are of greater impact worldwide: Scopus, Web of Science, IEEE, SciencieDirect EBSCOhost, Springer, the period of time covered are from 2014–2023, this for the relevance and timeliness of information that was obtained during that period, now well, in this same timeline 3000 studies were collected, then the process of inclusion and exclusion screening was performed thus remaining 142 articles, finally questions were applied Resident Internal Psychologist (PIR) until 41 articles were left.

3. Search strategy

For a quick verification and collection of scientific articles, an efficient strategy was used.(see **Table 1–12**)

Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• Items compatible with the findings required for the research. • Most recent research from 2014–2023. • Articles with great legal content and relevant findings.	• Articles not compatible with the data required for the present research work. • Research that is very obsolete and not very coherent in its thematic development. • Articles with little or no legal content and without any relevance in their findings.

Table 2. Main search strings and their results.

Database	Search strings	Method of inclusion and exclusion
Scopus	((neuro*or and law))	10
Web of Science	((neuro*or and law))	4
IEEE	((neuro*or and law))	4
Springer	((neuro*or and law))	2
EBSCOhost	((neuro*or and law))	3
Results	((neuro*or and law))	20

Table 3. Effectiveness of the results.

Database	Total, items	Relevant articles	Total accuracy
Scopus	35	10	5%
Web of Science	50	4	0,3%
IEEE	60	4	0,3%
Springer	4	2	0,1%
SciencieDirect	67	7	3%
EBSCOhost	50	3	0,1.5%

Table 4. Second database search and its results.

Database	Search strings	Method of inclusion and exclusion
Scopus	((neuro*or AND right))	4
Web of Science	((neuro*or AND right))	10
IEEE	((neuro*or AND right))	4
Springer	((neuro*or AND right))	2
EBSCOhost	((neuro*or AND right))	1
Results	((neuro*or AND right))	21

Table 5. Effectiveness of the results.

Database	Total, items	Relevant articles	Total accuracy
Scopus	1.736	0	16%
Web of Science	0	0	0,00%
IEEE	70	0	10%
Springer	0	0	0,00%
SciencieDirect	0	0	0,00%
EBSCOhost	30	3	0,1.5%

4. Neurolaw as an aid to criminal law justice

Since the dawn of science, there has been a desire to create a sophisticated method for the detection of lies in the arguments of criminals and with it to achieve a proper administration of justice by the magistrates, however, due to the minimal development of technology and science, these techniques were not achieved. Now, in this contemporary stage, science and technology as well as the various researches in neurotechnology are allowing us to have a better understanding of the brain and technology enables new ways of detecting and predicting human behavior through a technique called neuroimaging for White et al.[2]. They argue that neuroscientists seek to apply this technology to assess, treat, and better understand the complex socioemotional processes that underlie many ways of psychopathology likewise, Greely and Farahany, 2018[3]. Argues that the criminal justice system does not lag behind, as criminal law is interested in being able to understand the psychology and thinking of people who committed criminal acts. Altimus[4] outlines that science and the criminal system are concerned with human behavior and especially the mind. Also, this author believes that neuroscience would have great power to change criminal justice systems, and that society would benefit from an active collaboration between criminal law as a system and science.

Harris and Lawrence[5] assures that neuroprediction and lie detection neurotechnologies are a clear example of why it has become so essential to talk about neuroderivatives. for the author, neuroprediction comprises the use of structural or functional variables of the brain for medical predictions and behaviors of criminals. It should be noted that for Kiehl et al.[6] the use of neuroimaging data would be critical for predicting recidivism and criminal behavior of offenders. In that understanding, findings in neurocriminology have been

able to identify structural and functional deficits in the brain and their relationship with antisocial behavior in various individuals, Bellesi et al.[7].

Parallel to advances in neuroprediction, the use of neurotechnologies for lie detection has been explored. Efforts to detect lies have focused on measurements in the brain, believing that these may be more reliable than physiological responses in other parts of the body. Some studies used tools such as positron emission tomography, electroencephalography, functional near-infrared spectroscopy, and functional magnetic resonance imaging[8]. It is worth noting that the following table will demonstrate the use of neuroscience technique in criminal law.

Table 6. Published forensic diagnoses of actual cases where brain scans were used.

Ref.	Patient	Crime	Neuropsychology diagnosis	Neuropsychology	Images	Authors, conclusion
Gimeno H, et al.[9]	Hebert weinsten	Homicide	Arachnoid cyst in the frontal lobe	No	Positron emission tomography (Posttraumatic stress disorder (PTSD).	The authors conclude that the results of the diagnosis made to the defendant infer that he had mental insanity originated by the cyst in the brain.
Reeves D, et al.[10]	Vicente Gian Petro	Homicide	Schizophrenia, Alzheimer's disease or vascular dementia	IQ decrease of 40 points without neurological deficits	Pariental ipometabolism	The authors conclude that the diagnostic imaging performed on the processed brain failed.
Husted DS, et al.[11]	Bernie	violation	Epileptic seizures regular alcohol and cocaine abuse	Normal IQ (31) points difference between verbal IQ (76) and performance IQ (107).	Obvious atrophy of the medial left temporal lobe.	The researchers concluded that the findings obtained by nuroimaging are unclear.
Rigoni D, et al.[12]	JF	Neonaticide	History of multiple drug abuse, previous diagnosis of borderline personality disorder; antisocial characteristics.	High impulsivity, poor inhibition, deficits in emotional attribution, deficits in recognizing the behaviors that violate social norms.	Injured prefrontal cortex and reduced brain gray matter.	The authors conclude that, from the neuroimaging data obtained, the results expose a disinhibition and deficit in moral reasoning in the processed brain.
Hughes V[13]	Brian Dugan	Sexual abuse, pedophilia and homicide.	Sexual sadism	Not known	Gray matter reduced volume of matter in the left prefrontal bark as revealed by voxel-based morphometry (VBM)	The authors conclude that the results obtained by neuroimaging are difficult to analyze, given that the neuroimaging was performed 20 years after the criminal acts.
Sartori G, et al.[14]	Age of offender 64 years	Pedophile	Pathology compulsive, obsessive, infantile behavior, emotional anomalies of irritability and frustration.	Intellectual ability, above average, deficits in reasoning and morals, and a brain tumor was diagnosed.	Dysfunction in the orbigrontal cortex and frontal lobe.	The authors conclude that the tumor in the defendant's brain is the cause of the criminal behavior.
Scarpaz za C, et al.[15]	.....	Pedophilia	Variation in personality behavior.	disinhibition; dromo dysjective syndrome; continuous behavioral changes.	Frontal lobe atrophy	The authors conclude that, due to the brain lesion of the defendant, the deviant behaviors are originated.

Source: Chandler et al.[16].

5. The technique of neuroimaging as an evidentiary value in courtrooms

For Sinnott-Armstrong.[17] assures that neuroimaging technology has revolutionized the field of medicine and law, thus with the new research is beginning to understand the associations between the brain and human behavior, and how these can help to improve the judicial system, now well these neuroimaging techniques will contribute radically to the diagnosis of the offender and the problem associated with his brain with the criminal offense, also could be achieved decipher the neural code and anomaly of the same, such diagnostic result could be considered as a means of evidence in the courts of law. It should be noted that new imaging techniques are used for a proper diagnosis of the brain, including. positron emission tomography (PET), single photon emission tomography (SPECT), nuclear magnetic resonance (MRI), functional magnetic resonance imaging (IRM), diffusion weighted images (DWI), diffusion tensor (DTI), magnetic resonance spectroscopy (MRS), susceptibility weighted imaging (SWI) and magnetoencephalography (MEG), all of which provide an unprecedented view of anatomical structures and/or functions in the human brain.

Following the same reasoning, neuroimaging has provided a comprehensive understanding of brain development and its drastic changes in adolescents, as in the case (Simmons, 2005; Florida, 2011; Alabama, 2012)[18]. The Supreme Court ruled on the basis of neuroscientific research findings that the frontal lobes of the brain do not reach full maturity until the mid-20s, or even later. The legal implications of these findings were fundamental in determining that the execution or an automatic sentence of life imprisonment without possibility of parole for someone under the age of 18 should not be carried out, since the condition of immaturity in the cerebral aspect can be a case of mitigation or even a case of exemption from punishment in adolescents.

Table 7. Use of brain scanner in actual trials and their respective sentences by the court (Source: Own elaboration).

Author	Use of the mechanisms of neuroimaging as a means of evidence	Importance for the judicial system
Morse S, 2015[19]	With advances in neuroscience, judicial careers will become more complex, as judges will be asked to determine the admissibility of neuroimaging expert testimony in courtrooms.	The importance of this method will be in the opinion of a professional in neuroscience that will serve as evidence in the trial system.
Ligthart S, 2019[20]	In Italy, a well-known sentence of the Court of Assised'Appello. The importance lies in the fact that the court has recognized an of Trieste, has ratified for the first time the use of neuroscience to prove individual unimputability.	The importance lies in the fact that the court has recognized an anomaly in the defendant's brain, calling it "the partial vice of mind", this mental illness is the origin of the criminal's reprehensible behaviors such as violence and aggression.

6. Neurolaw as a threat to fundamental rights

Neuroscience could help criminal justice with its sophisticated methods, however, it causes controversy, since human rights would also be at risk with this system, according to Yuste et al.[21], proposes to create four neurospecific human rights: cognitive freedom, psychological continuity, mental privacy and integrity. Likewise, the same author argues that today the NeuroRights Foundation, stimulates the creation of five NeuroRights: the right to free will, mental privacy, personal identity, fair access to mental augmentation and protection against prejudice. It should be noted that the impact of the aforementioned rights has been so great that the Chilean Congress approved on 12 April 2021 a Constitutional Reform that defends the rights to physical and psychological integrity, arguing that fundamental rights are progressive and not regressive.

Now, for the IACHR[22], it points out that rights are always progressive and not regressive, as previously mentioned, this is typified in the universal declaration of human rights, specifically in its preamble. The principle of progressivity is subsumed in the obligation of non-regression, which means that advances in human rights are irreversible, they can always be increased, but never restricted, likewise the American Convention on Human Rights (hereinafter ACHR) outlines in its article 1.1. The States Parties to this Convention undertake to respect the rights and freedoms recognized herein and to ensure to all persons subject

to their jurisdiction the free and full exercise of those rights and freedoms, also following the ideas of the same international norm in its article 5.1. No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment. Everyone deprived of his liberty shall be treated with respect for the inherent dignity of the human person. However, another international treaty, the International Covenant on Civil and Political Rights (hereinafter ICCPR), prescribes Article 18 1. Continuing with the same reasoning for Asgher et al[23], he points out that the European Convention on Human Rights (hereinafter ECHR), radically prohibits the affectation of the rights to psychological freedom and integrity of the person, this without any exception, since, These rights are recognized in article 3 of the ECHR, "No one shall be subjected to torture or to inhuman or degrading treatment or punishment", it is worth mentioning that if neuroscience were to be applied, it would cause suffering and humiliation to the human person, it would be like torture or even inhuman and degrading treatment. It is for these reasons that the application of neurolaw to the judicial system would bring with it great legal dilemmas.

Table 8. Potential rights affected by the neuroscience approach to some Latin American countries (Source: Own elaboration).

Country	State supreme law, title and chapter	Article and right violated
Peru	Political Constitution/Title I. Of the person and society. Chapter II. Fundamental rights of the person.	The defense of the human person and respect for his dignity is the supreme aim of the State and society. Article 2.1. to their moral, psychological and physical integrity and to their free development and welfare Article 2.23.h. No one shall be a victim of moral, psychological or physical violence, nor subjected to torture or inhuman or humiliating treatment.
Colombia	Political Constitution/Title I. Of the fundamental principles. title II with concordance to chapter II. Fundamental Rights.	Democratic, participatory and pluralistic, based on respect for human dignity. Freedom of conscience is guaranteed. No one shall be molested on account of his convictions or beliefs, nor compelled to reveal them, nor forced to act against his conscience.
Chile	Political Constitution/Chapter I. Bases of the Institutionality. Chapter III. Constitutional rights and duties.	Persons are born free and equal in dignity and rights. The right to life and to the physical and psychological integrity of the person.
Uruguay	Political Constitution/Section II in accordance with Chapter I.	The right to life and to the physical and psychological integrity of the person.
Mexico	Political Constitution/Title I Chapter I. Human Rights and their Guarantees.	Any act or any other act that violates human dignity and has the purpose of nullifying or impairing the rights and freedoms of persons is prohibited. Article 29. In the decrees issued, the exercise of the rights to life, personal integrity, freedom of thought, conscience and the prohibition of torture may not be restricted or suspended.
Paraguay	Political Constitution/Title I. Fundamental Declarations. Title II. Of the rights, duties and guarantees.	The Republic of Paraguay adopts for its government a representative, participatory and pluralistic democracy, based on the recognition of human dignity. Every person shall be protected by the State in his physical and mental integrity, as well as in his honor and reputation.
Ecuador	Political Constitution/Chapter II. Civil rights.	Article 23, 2. Personal integrity. Cruel punishment, torture, any inhuman or degrading procedure or any procedure involving physical, psychological or sexual violence or moral coercion, and the application and improper use of human genetic material are prohibited. Article 23, 11. Freedom of conscience.
Bolivia	Political Constitution/ Title One Fundamental Rights and Duties of the Person.	Article 6. The dignity and freedom of the person are inviolable. To respect and protect them is a primary duty of the State.
Dominican Republic	Political Constitution/ Title I. Of the nation, the state, its government and its fundamental principles. Chapter I. Of the nation, its sovereignty and its government. Section I. Of civil and political rights.	The Constitution is based on respect for human dignity and on the indissoluble unity of the Nation, the common homeland of all Dominicans. Every person has the right to respect for his physical, psychological and moral integrity and to live free from violence.

7. Neurolaw and the control of brain activity

Some authors such as Delgado[24] point out that "The individual is defenseless against direct manipulation of the brain, because he is deprived of his most intimate mechanisms of biological reactivity. In experiments, electrical stimulation of appropriate intensity always prevailed over free will; and, for example, hand flexion caused by stimulation of the motor cortex cannot be avoided voluntarily. The destruction of the frontal lobes produced of changes in affectivity that are beyond any personal control." According to Levy[25], he stresses that the use of neuroscience could produce a very nefarious event, given that brain stimulation could produce a population of slaves or robots, furthermore he concluded by arguing that "Brain stimulation technology should be examined in other contexts besides those related to the very remote possibility that it could be used to control individuals or groups of people".

8. Bayesian inference theory, fuzzy logic and quantum mechanics

In the words of Pouget et al.[26], some of the computational theories of structural learning are based on the same probabilistic framework that has been used to understand inference and learning in neural circuits and involve operations such as marginalization, in that sense, there is hope that the type of neural mechanisms based on a structural system can determine and predict the functioning of the brain in connection with neurons, likewise Gentili[27] assures that fuzzy logic plays an important role in the field of artificial intelligence, since it is good for computing human actions and capabilities. Recently, it has been shown that fuzzy logic is also processed at the molecular, supramolecular level, while the neuroscience of fuzzy logic promises to be fertile in the development of new interdisciplinary knowledge, to which its application in the field of law can be added.

Quantum mechanics is that scientific theory that is interested in discovering any natural phenomenon from a perfective analysis of atoms and subatomic particles, it was first coined by Bohr and Rutherford in the early twentieth century, quantum mechanics states that its application consists of exact results, this means that taken to the field of neuroscience and applied to the legal field, predictions in criminal minds would have an exact certainty and probability.

9. Right to free will

For the neurophysiologist McCay and Kennett[28] all behaviors, as well as human emotions and feelings, are produced by neural processes, he also adds that whatever we think is the result of processes that are influenced by many factors (hormones, neurotransmitters, synaptic connections) and these factors determine a person's behavior. What makes us choose depends on the organization of the brain, therefore, free will is considered only a "space of possibilities."

Vitacco et al.[29] assures that everything we think are physically recorded in the neural circuits of our brain and all that structure of thought is called "mental frames", these frames constitute for the human being as a source of structuring our ideas, thoughts, choices and visions about the world. It is worth noting that this author states the idea that free will can only operate on what is in our brain, on its content of ideas.

In my opinion I can outline that free will is a natural right granted to man by divine laws, which means having a final control over our own decision making, without unknown manipulation of external neurotechnologies, in that same reasoning no one can attempt against the integrity and full development of the free will of the human person, however, throughout our history of mankind were put on topics of debate on this point, philosophers were responsible for studying them, but little were the results obtained. It is necessary to point out that after a long time two antagonistic positions emerged: compatibilism and incompatibilism. Muñoz et al.[30] on the one hand believes that compatibilism supports the idea that it is metaphysically plausible the notion that by nature the human person has free will, on the other hand, incompatibilism assures with a

thesis contrary to the first assertion, since it indicates that our actions are deterministic or truly random events and both possibilities exclude free will and moral responsibility. Now, some authors such as Belger et al. [31] suggest that it would be a bit difficult to try to elevate "Free Will" as a category of human rights seems deeply complicated in conceptual terms.

10. Results

Table 9. Main results and their characteristics (Source: own elaboration).

Authors/article/year	Objectives	Importance
From neuroscience to law: bridging the gap (Pernu TK and Elzein N, 2020[32])	The core objective of this research was to highlight three different ways in which neuroscience may, or may not, be used to inform our moral and legal judgments. First on the functioning of the active subject's brain, second to verify its implications on the subject's behavior, third to analyze whether free will is affected.	The importance of this research lies in the idea of drawing from and analyzing neuroscience and other physical views on human behavior and decision making and discovering whether such a technique has the potential to have a positive impact on our legal reasoning.
Neurorights vs. neuroprediction and lie detection: The imperative limits of the criminal law (Rodriguez D and Soto B, 2022[33])	This article aims to analyze the suitability of neurorights to limit the use of neuroprediction and lie detection neurotechnologies. In addition, it is pointed out that some of their applications in criminal proceedings should be prohibited, as they are severely intrusive to mental privacy and contrary to the dignity of the person.	The importance of this study is subsumed in the idea that the human rights in force must be interpreted in such a way as to respect the dignity of the accused in the criminal process.
Neurosociology and penal neuroabolitionism: rethinking justice with neuroscience (Rodriguez D and Borbón LA, 2022[34])	The central objective of this research is to analyze and prevent criminogenic social factors, and from a critical perspective on free will as a narrative to justify criminal law as a control mechanism.	The importance lies on the impact of neuroscience in the field of criminal law and how it directly affects the fundamental rights of the human person, his free will and dignity.
Human neuro-rights (Farinella F and Gulyaeva E, 2022[35])	The main objective of this research is to analyze the basic characteristics of the proposal to enforce new human rights based on new technologies applied to Neuroscience.	The importance is prescribed in this research in the idea that the use of neurotechnology will affect our way of life on the ground, as well as the very nature of what we understand today as human beings, and also the nature of the administration of justice.
Neurociencia y Derecho: El impacto del Neuroderecho en la práctica judicial (Brito & Soto)[36])	The central research objective is to examine the legal implications of these neuropsychological findings in a European context thus subordinated in the light of the principle of rehabilitation as interpreted in the jurisprudence of the European Court of Human Rights.	The importance is conceived in the idea that the use of neurotechnology applied to the law itself can be considered as an aversion to the rights of individuals, this interpreted in the light of the jurisprudence of the European Court of Human Rights (hereinafter ECHR).
Assessing risk among correctional community probation populations: Predicting reoffense with mobile Neurocognitive Assessment software (Haarsma et al) [37])	The main objective of this research was to analyze from several theoretical arguments the development of neuroscience in law and the judiciary.	The importance of this study lies in the basis of analysis and the support of neuroscience to the judiciary, in obtaining evidence directly from the neuroscience approach.
The Limited Relevance of Neuroimaging in Insanity Evaluations. Neuroethics (Vitacco et al) [38])	The main objective of this research is to determine the application of neuroscience to criminal proceedings and its repercussions on the administration of justice by magistrates, since they can mitigate or exempt the sentences of defendants depending on the degree of mental anomaly of the active subject.	The importance is seen in the analysis of the various individuals, who with the help of neuroscience could contribute to the lower prediction of brain dalos.
NeuroHuman Rights and Criminal Neuroabolitionism: Critical Remarks on Neuroprediction and Lie Detection (Asamizuya et al., 2022[39])	This paper aims to critically address the desirability of creating new human neuro-rights to address the use of neuroprediction and lie detection technologies in criminal matters.	The importance of this research lies in the fact that Chile was the first Latin American country to adopt the nudelaw method in its national legislation.

Table 9. (*Continued*).

Authors/article/year	Objectives	Importance
Towards new human rights in the age of neuroscience and neurotechnology(Ienca y Andorno) [40])	The five NeuroRights proposed by the NeuroRights Initiative. This analysis seeks to offer some critical insights regarding challenges in free will, enhancement, identity, algorithmic bias, and privacy.	This article focuses on some conceptual, practical, ethical and logical issues that must be considered in determining whether these NeuroRights should become a global policy.
Neuroscience in forensic psychiatry: From liability to dangerousness. Ethical and legal implications of using neuroscience for dangerousness assessments. (Gkotsi GM and Gasser J, 2016[41])	The goal of this research is to critically examine the promise of neuroscience to serve a better criminal justice system by offering new and more reliable tools for assessing offender dangerousness.	The importance of this same work was to expose the notions of free will and the responsibility of neuroscience, as well as its implication in our criminal justice system, moving away from retribution-motivated sanctions towards crime prevention and rehabilitation.
Mild traumatic brain injury: Is DTI ready for the courtroom? (Shenton ME et al., 2018[42])	The objective of this research is to expose the important role that the use of neuroimaging in the court of law would have.	The importance of this research lies in the idea that, thanks to new scientific research in neuroscience, a scenario is being captured where presidents and rulers of various nations, within the precincts of fundamental norms and rights, can use neuroscience in criminal proceedings in the right way.
Neurolaw in Latin America: Current Status and Challenges (García-López E et al., 2019[43])	The objective of this article was to facilitate evidence-informed public policy by examining the current state of neurolaw in Latin America.	The importance of this research is conceived in order to create new rights in Latin America, which serve to protect the dignity and freedom of human conscience.

Table 10. Results using the technique of applying neuroscience to law (Source: Own elaboration).

Authors	Applied technique	Results
(Arun V and Kafaltiya, 2020[44])	Brain electrical oscillation oscillation signature profiling (BEOSP) test value	The Brain Electrical Oscillation Signature Profiling technique was developed in 2003. BEOSP techniques are available at three locations in India, Mumbai, Chandigarh and Gandhinagar. More than 300 criminal suspects underwent this method and the results are astounding, as the results significantly helped the judicial field.
(Cunningham W et al., 2001[45]).	The Autobiographical IAT (Implicit Association Test)	A new lie detection technique is the "Forensic-IAT". The IAT test is a methodology aimed at detecting a memory trace (memory detector) which was introduced by Professor Sartori of the University of Padua. The results of this technique are automatic, i.e., it predicts and detects the lies of the accused in a few seconds.
(CapraroL, 2016[46])	Brain fingerprinting technique	This form of technology consists of a recording of potential correlates to events coming from the outside, performed by means of an EEG, carried out while the subject under study was wearing a helmet with electrodes. The device was licensed in the 1980s and invented by Lawrence Farwell, who was a neuroscientist at Harvard University. The results are interesting, since this method allows, by means of an anomalous wave, called "P300", to reconstruct facts of the crime through the analysis of the brain.
(Sartoi G et al., 2020[47]).	Brain imaging technique	According to the Royal Society's 2011 report on neuroscience and the law. According to the 2011 Royal Society report on neuroscience and law in the USA, neuroscientific evidence (mainly neuroimaging and genetics) has been used in more than 800 cases of murder, manslaughter, assault and kidnapping. The results indicate that this method is 70% effective in detecting criminal incidents carried out by the accused.

11. Discussion

The results obtained in this research indicate that the use of neuroscience focused on law will be an inevitable reality, due to the progress of science and technology, however, its proliferation throughout the world will bring great legal dilemmas and its correct application will be debated, but it is expected that the use of neurolaw will have a suitable approach and will be approached from a human and ethical worldview for its respective application.

Table 11. The application of neuroscience to law and its results (Source: Own elaboration).

Technique reference	Application to law	Results	Conclusions
Neuroprediction and AI in forensic psychiatry and criminal justice: A neurolaw perspective[48]	Applied to law following a pattern of recidivism prediction and lie detection in the criminal process, this technique could be called AI neuroprediction.	The results of their study show that a predictive model involving neural measures of brain age performed better than previous models involving only psychological and behavioral measures.	The authors conclude that there is a long way to go in the use of the neuroprediction technique, as well as to learn more about its implications in law.
Neuroscience in Juvenile Criminal Law: Reconsidering Sentence Measurement in Latin America[49]	Its application to law is important because thanks to neuroscience it is being possible to detect and understand the development of brain procedure, especially in the relationship between adolescent behavior and the ability to control and their impulsive reactions.	The results concluded that the application of neuroscience to the judicial procedure of adolescents can reduce or mitigate their culpability and also the amount of the sentence imposed.	The authors concluded by highlighting the importance of neuroscience in criminal justice and how it could revolutionize the field of justice and its proper application.
Rewiring blame: how advancing neuroscience fosters strategic interventions on retributive justice[50]	Its application to the field of law would be denoted in the use of neuroimaging to detect and decipher the neural code of the defendant, this would allow the judge to have a better management of the administration of justice.	The results determined two important findings: 1) neuroimaging could predict the decision point and the actions of the active subject. 2) the ability to apply machine learning algorithms to accurately predict the movements of the subjects before they decide to perform the criminal acts.	The authors conclude that over the years the penalty for the most lethal criminals has been increased; however, little is known about how these criminals committed their crimes, so neuroscience and its correct application to justice would allow deciphering the true origin of the crime and its respective attenuation to the punishable act.
Neuroimaging in criminal trials and the role of psychiatric experts: a case study[51]	Thanks to neuroimaging and its respective application to the field of law, it would serve as a set of neuropsychological neuroimaging behavioral evidence and this could paint a rich portrait of a defendant's brain dysfunction and its causal role in the criminal behavior in question.	The results of this research point to the legal context of the following cases: e.g., in European cases, out of a total of five cases, three cases were on appeal. In U.S. cases, neuroimaging techniques are used in various contexts: for legal defenses of insanity and determination of the defendant's mens rea (ten cases, of which eight cases are on appeal) and for mitigation purposes at the sentencing stage of criminal proceedings. procedure (in the twelve cases we examined, the death sentence was appealed).	The authors conclude that neuroscience through the neuroimaging technique is a very viable option to revolutionize the penal system, in order to detect the behaviors that originate the criminal act emanating from brain activity.

Table 12. Advantages and disadvantages in the implementation of neuroscience in the law (Source: own elaboration).

Author	Advantages	Disadvantages
García-López et al [52]	The authors point out that the advantages of the use of neuroscience would be evidenced in the attenuation or exoneration of the guilt of the defendant, depending on the diagnosis obtained by the technique in question.	The authors also outline that one of the disadvantages would be observed in the accuracy of the neuroimaging technique in detecting or deciphering the subject's neural codes.
(Llamas NE & Marinaro, 2021[53]	The author mentions that its use can serve both noble causes (such as the rehabilitation of people suffering from some kind of disease), as well as crimes of a severity that could only be imagined in science fiction literature.	The author mentions that the disadvantage in using neuroimaging would stand out when it is capable of mapping the human brain, thus deciphering private data, not necessarily related to the criminal process.
(Moore M, 2022[54]	The advantages of neuroscience would be most noticeable in the field of medicine and little would be the contribution in the field of law, due to its controversial use.	The author refers that neurotechnological interventions that alter human thought and behavior are absolutely against legal and human ethics, besides eroding human dignity.

Notes

Sources: Thesaurus of Latin American Criminal Policy, United Nations Interregional Crime and Justice Research Institute—UNICRI).

Conflict of interest

The author declares no conflict of interest.

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