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The Role of Neuroprediction and Artificial Intelligence in the Future of Criminal Procedure Support Science: A New Era in Neuroscience and Criminal Justice

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Abstract
Recent developments in the field of neuroimaging in the world of neuroscience, when combined with artificial intelligence and, more specifically, with the use of mechanical engineering, have resulted in the creation of brain reading technology that may soon be widely used in scientific fields in the world including detecting, for example, criminal lies. When used in forensic psychiatry, this approach can increase the precision of risk assessment and help determine areas where intervention can be most effective. Neuro prediction with artificial intelligence can be called AI. This neuroprotection is a method of predicting criminal behaviour by finding biomarkers of brain function that can indicate that someone is committing crimes in the future. Normative legal research or library legal research (library research), with a statute, conceptual, comparative, historical, or futuristic approach. The nature of the research used in this research is descriptive-prescriptive and uses content analysis. The result of this research is to dissect the development of AI Neuroprediction in forensic psychiatry and criminal justice with attention to this technology's legal and ethical implications and potential applications. In the future, AI neuroprediction may play an important role in integrating forensic psychology into the criminal justice system. Through in-depth analysis of neurological data, AI neuroprediction could assist in identifying behavioral patterns or tendencies that might influence a person's criminal propensity, thus enriching traditional forensic psychological evaluations. It may also contribute to creating more precise and personalized intervention strategies to prevent repeat crimes.
Keywords: Neuroprediction; Artificial Intelligence; Neuroscience; Forensic Psychiatry; Neurolaw.

Introduction

Article 1, paragraph 3 of the 1945 Constitution of the Republic of Indonesia confirms that Indonesia is a country based on law.[1] Therefore, every citizen must submit and comply with the applicable regulations. Law is always required to answer the problems and changes society faces in the shifting times.[2] It is believed that society will always be able to find the answer in law. This aligns with the development of industrial revolution 4.0 and Society 5.0, which are currently underway.[3] Even amid the issue of criminal law enforcement in the Indonesian justice system, it often becomes a point of public attention. This is because there needs to be a reflection of a sense of justice and legal certainty in law enforcement. Law enforcement is seen as unfair and biased, often harsher towards specific groups, which results in a downgrade of the overall image of law enforcement. Ironically, society has begun to form a mindset that law enforcement is biased and more burdensome to specific groups, with the impression of being "sharp downwards and blunt upwards". This condition has reached an alarming stage and has become the focus of legal issues in Indonesia.[4] Societal changes influence the evolution of human behaviour and thinking in general information technology, communication technology, and knowledge. If a crime is involved, it influences or causes an increase in the quality of the crime itself, which causes many criminal cases and cannot be resolved by criminal law and criminal procedure law, so it requires other disciplines to uncover or resolve them and to seek material truth.[5]

Evaluating potential harm is an integral part of the criminal justice system.

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[1] Leli Tibaka dan Rosdian Rosdian, 'The Protection of Human Rights in Indonesian Constitutional Law after the Amendment of the 1945 Constitution of the Republic of Indonesia' (2018) 11 Fiat Justisia: Jurnal Ilmu Hukum.[266].

[2] Thomas Prehi Botchway dan Abdul Hamid Kwarteng, 'Developing International Law in Challenging Times' (2018) 11 Journal of Politics and Law.[53].

[3] Paulus Wisnu Yudoprakoso, 'Simposium Hukum Indonesia' (2019) 1 Kecerdasan Buatan (Artificial Intelligence) sebagai Alat Bantu Proses Penyusunan Undang-Undang dalam Upaya Menghadapi Revolusi Industri 4.0 di Indonesia.[574].

[4] Hidayatullah Hidayatullah, 'Legal Protection for Justice Collaborators in Indonesia's Criminal Judiciary System' (2019) 35 Yuridika.[280].

[5] Kompasiana, 'Ilmu Bantu Dalam Hukum Pidana' (*www.kompasiana.com*, 2014) < https://www.kompasiana.com/bloggernes/55281d676ea83403378b45a7/ilmu-bantu-dalam-hukum-pidana>.

Forensic psychiatry and criminal justice have seen a recent increase in research and development of new methods for risk assessment. More than two hundred violence risk assessment tools are already available to predict aggressive, antisocial, and sexual human behaviour, and their use appears to be increasing in the context of criminal justice in several countries worldwide.[6]

The main objective of this tool is to accurately categorize criminals into high-DDJDJrisk and low-risk categories. They are used to inform various medico-legal options, including conviction, parole, death penalty, disposition in juvenile court, and release after a finding of insanity or insanity. Neuroprediction with artificial intelligence (artificial intelligence), called AI Neuroprediction, has been used in recent years to improve the accuracy and prediction of risk assessment.[7] Algorithmic risk assessment has become increasingly popular due to neuroimaging research, which is a computational/quantitative technique used to study the structure (structural imaging) and function (functional imaging) of the central nervous system, whose aim is to scientifically study the healthy human brain in a non-invasive way. Medical action without inserting tools into the body, without causing damage to the skin or cavities of the human body, has progressed, resulting in the development of so-called "brain reading" techniques that could, in theory, at least, decode a person's mental state from their brain activity or group them into groups according to their brain anatomy and function. This approach can be used in forensic psychiatry, especially in detecting potential criminals. Use of structural or functional brain parameters paired with machine learning methods to make clinical or behavioural predictions in the presence of neuroprotection with artificial intelligence. With the development of science going forward, maybe in the not-too-distant future, forensic psychiatry and criminal justice can take advantage of AI.

Additionally, there has been a surge in interest in and study of violence

[6] Lisa Fadiyah, 'Apa Saja Macam-Macam Teknik Pencitraan Otak?' (*kompasiana.com*, 2022) <https://www.kompasiana.com/lisafadiyah5708/623e4fb4ba21bc32ed64d6a3/apa-saja-macam-macam-teknik-pencitraan-otak>.

[7] Leda Tortora and others, 'Neuroprediction and A.I. in Forensic Psychiatry and Criminal Justice: A Neurolaw Perspective' (2020) 11 Frontiers in Psychology.[1].

risk assessment tools in the last two decades, with methods ranging from purely actuarial (regression-based) to algorithmic (providing probabilistic estimates of re-occurrence) to structured (relying on professional judgment). Initially, actuarial approaches (a branch of science that applies mathematical methods using statistics to assess risk) were standard, despite having little or no predictive power. Individual qualities (criminogenic needs) that increase the risk of recidivism, as well as demographics, socioeconomic level, and intellectual intelligence (IQ), are all risk variables associated with a higher likelihood of violent or aggressive behaviour.

This study was designed to explore and understand the concept of AI-based Neuroprediction and how these elements interact within the cognitive, ethical, and legal neuroscience framework. Neuroprotection refers to the ability to predict individual behaviour based on brain activity patterns. In this context, AI becomes an essential tool in processing and analyzing complex and large amounts of brain data. On the other hand, cognitive neuroscience is a field of study that focuses on how the brain processes information and how this process influences the way we think, learn, and behave. Through this approach, we can understand how brain activity patterns can relate to certain behaviours and how AI can be used to predict them. However, this research is about more than just technology and science. Ethics and law are other essential components. In applying this technology and science, we must consider its impact on individuals and society. For example, how do we ensure brain data privacy and security? How can we ensure that the predictions generated are fair and non-discriminatory?.

Moreover, how can we ensure that this technology complies with applicable law? Thus, the background of this research is to understand and explain the concept of AI Neuroprediction and how its components, namely cognitive neuroscience, ethics, and law, interact. The goal is to find the best way to utilize this technology in an ethical and legal context. Research is an activity that seeks the truth of science, where research is born from doubts or curiosity about a problem.[8] The research

[8] Peter Machmudz Marzuki, 'The Essence of Legal Research is to Resolve Legal Problems' (2022) 37 Yuridika.[37].

entitled "The Role of Neuroprediction and Artificial Intelligence in the Future of Criminal Procedure Support Science: A New Era in Neuroscience and Criminal Justice" examined library materials or secondary data, which can be called normative legal research or library research.[9] This research collected primary, secondary and tertiary legal materials.[10] In this study, an analysis will be made using several approaches, namely: statutory approach, conceptual approach, comparative approach, and futuristic approach.[11] In addition, this study uses descriptive and prescriptive characteristics. After that, the materials that have been collected will be processed, accompanied by an analysis that strengthens the results of this study.[12] The research uses content analysis.[13]

Roles and Functions of Auxiliary Science in Criminal Procedure Law in Indonesia

Criminal procedure law, formal criminal law or KUHAP (the Book of Criminal Procedure Code), is an integral part of the criminal law system. It is a set of rules and regulations that govern how material or substantive criminal law is applied and enforced. While material criminal law defines what constitutes a criminal act and its sanctions, criminal procedural law establishes the procedures and mechanisms used to enforce said law. In the context of criminal law in Indonesia, the Criminal Procedure Code is a law that is used as the primary reference in the criminal law enforcement process. This law, known as Law Number 8 of 1981, covers various aspects

[9] Zico Junius Fernando. [*et.al.*], 'Deep Anti-Corruption Blueprint Mining, Mineral , and Coal Sector in Indonesia' (2023) 9 Cogent Social Sciences [1] <https://doi.org/10.1080/23311886.2023.2187737>.

[10] Zico Junius Fernando, [*et.,al.*], 'The Freedom of Expression in Indonesia' (2022) 8 Cogent Social Sciences.[1].

[11] Gusalim, [*et.,al.*], 'Green Victimology: Sebuah Konsep Perlindungan Korban dan Penegakan Hukum Lingkungan di Indonesia' (2022) 7 Bina Hukum Lingkungan.[60]. <10.24970/BHL.V7I1.302>.

[12] Bambang Waluyo, *Penelitian Hukum Dalam Praktik* (Sinar Grafika 2007).[40].

[13] Zico Junius Fernando et al, 'Preventing Bribery in the Private Sector Through Legal Reform Based on Pancasila' (2022) 8 Cogent Social Sciences.[1]. <https://doi.org/10.1080/23311886.2022.2138906>.

of the criminal justice process, including investigation, prosecution and trial. Criminal procedural law is vital in ensuring justice in the criminal justice process. Through the rules and procedures set out in the Criminal Procedure Code, parties involved in the criminal justice process can ensure their rights and obligations are respected. For example, the Criminal Procedure Code includes provisions regarding defendants' rights, including the right to be represented by a lawyer, the right to defend oneself, and the right to a fair and speedy trial. Criminal procedural law also ensures that the government complies with the rule of law in enforcing criminal law. This includes ensuring that law enforcement is carried out in a proportionate manner and that the government does not abuse its powers in the law enforcement process. Thus, criminal procedural law plays a vital role in maintaining justice and human rights in the criminal law system.[14]

According to Van Bemmelen, the objectives of criminal procedural law, as stated in the KUHAP Implementing Guidelines as quoted above, can be formulated into three functions, namely:[15]

1. Seek and Find the Truth

   This objective relates to efforts to reveal what happened in a case. This process involves gathering and analyzing evidence, examining witnesses, and examining defendants. In this case, investigators, prosecutors, and judges all work together to ensure that the facts of the case are revealed, and the truth is found. This function is essential because without absolute and objective truth, justice cannot be achieved;

2. Giving a Decision by a Judge

   After the facts have been determined and the truth has been found, the judge then takes a role in making a decision. This decision is based on applicable law

[14] Syahidah Izzata Sabiila, 'Hukum Acara Pidana: Definisi, Tujuan Hingga Asas Yang Berlaku' (*news.detik.com*, 2022) <https://news.detik.com/berita/d-6015557/hukum-acara-pidana-definisi-tujuan-hingga-asas-yang-berlaku>.

[15] Modul Hukum Acara Pidana Diklat Kejaksaan RI, 'Tujuan Dan Fungsi Hukum Acara Pidana -' (*berandahukum.com*, 2020).

and the evidence presented during the court process. Judges need to ensure that their decisions are fair and unbiased and that the rights of the accused have been respected throughout the process.

3. Implement Decisions

   After the judge has decided, the next step is implementing the decision. This can be detention, imprisonment, fines, or other forms of punishment. This decision must be implemented in a manner that complies with the law and respects human rights. If criminal sentences are given, the government must also ensure prisoners' rights are respected and receive proper facilities and humane treatment.

So, every stage in the criminal law process, from investigation to enforcement of decisions, aims to achieve justice and legal certainty.[16] Through these three functions, criminal procedural law seeks to ensure that everyone gets their right to a fair legal process and that criminal law is enforced fairly and proportionately. The statement above shows that the main task of criminal procedural law is to enforce or concretize material criminal law. Someone who has committed a crime, such as theft or murder, can be punished like other crimes: through investigation, prosecution, court decision, and execution of the decision. The goal of any criminal case is to establish legal clarity and justice, which requires criminal law and criminal procedural law to work together.[17]

Advances influence human thought and behaviour changes in information technology, communication, and scientific understanding. Criminal law and criminal procedural law cannot handle many criminal cases alone. Therefore, criminal procedural law must try harder to uncover by getting help from other disciplines to seek material truth.[18] The auxiliary sciences of criminal procedural law include logic, psychology, criminalistics, psychiatry, and criminology. Logic guides clear

[16] Luh Putu Kristyanti, 'Saksi Ahli Sebagai Alat Bukti Dalam Hukum Acara Pidana Indonesia' (2020) 8 Kertha Semaya : Journal Ilmu Hukum.[1429].

[17] I Nyoman Sukandia, I Nyoman Putu Budiartha dan Ketut Adi Wirawan, 'Penal Mediation in the Criminal Law as a Shift in Social Contract Theory' (2020) 35 Yuridika.[560].

[18] Putu Tissya Poppy Aristiani dan I Wayan Bela Siki Layang, 'Pengaturan Alat Bantu Pendeteksi Kebohongan (Lie Detector) di Pengadilan Dalam Pembuktian Perkara Pidana' (2022) 10 Kertha Semaya : Journal Ilmu Hukum.[506].

and logical reasoning during legal proceedings, enabling law enforcement to make valid inferences and formulate solid arguments. Psychology is used to understand individual motivations and behaviour, provide in-depth insight into the reasons and methods of crime, and assist in evaluating the credibility of witnesses and victims. Criminalistic disciplines assist in collecting and analyzing physical evidence and provide a better understanding of how crimes were committed. Psychiatry provides insight into the mental state of offenders and how these conditions might affect their behaviour; this is particularly important in cases where the perpetrator's mental status is a crucial consideration. Criminology, the study of crime and criminal behaviour, assists in understanding the social and economic factors that influence criminal behaviour and helps formulate prevention strategies. By leveraging these disciplines, criminal procedure law can more effectively discover the truth, deliver justice, and respond to the challenges posed by technological and social change.

As a clear example of the importance of other disciplines in criminal law enforcement, we can look at the 2016 case involving Jesika Kumolo Wongso, who was accused of killing Wayan Mirna Salihin.[19] The case gained public attention through live coverage on television. In this law enforcement process, various disciplines' roles are clearly visible. In investigations and trials, testimony from psychiatrists, doctors and other medical professionals is crucial in uncovering the truth behind these events. They provided evidence that helped the judge conclude that Jesika was responsible for the cyanide poisoning in Mirna's coffee. This example illustrates how, in the process of investigating and prosecuting criminal law violations, the use of other disciplines or auxiliary sciences is very important. In short, material truth in a criminal case can often only be fully uncovered with help and insight from other disciplines.

The existence of auxiliary science in criminal procedural law and the increasingly complex social and cultural context in which crimes occur are essential.

[19] Muhyiddin, 'Hakim: Jessica Terbukti Secara Sah Membunuh Mirna' (*https://news.republika.co.id*, 2016) <https://news.republika.co.id/berita/ofpb43361/hakim-jessica-terbukti-secara-sah-membunuh-mirna>.

Criminal behaviour often reflects broader cultural trends and dynamics, and this is most evident in the way crime has evolved and adapted as technology and social structures have changed. For example, criminal acts such as smuggling, corruption and hacking in Information and Electronic Technology (ITE) are examples of how forms of crime have developed along with the times. Smuggling reflects the challenges of globalization and international trade, corruption reflects problems in government structures and public policies, and ITE hacks show the impact of the digital revolution and our dependence on technology. Criminal procedural law must involve and utilize auxiliary knowledge from various other disciplines to handle and resolve these crimes. Knowledge of social dynamics, psychology, technology, and other aspects is essential to uncover and understand these increasingly complex crime cases. In other words, assistive science in criminal procedural law is helpful and has become very important and relevant amid the development and complexity of crime in the modern era.

Without involving auxiliary disciplines, seeking material truth and providing proper justice in many criminal cases today will be challenging. Criminal procedural law must involve and utilize auxiliary knowledge from various other disciplines. Knowledge of social dynamics, psychology, technology, and other aspects is essential to uncover and understand these increasingly complex crime cases. In other words, assistive science in criminal procedural law is helpful. It becomes essential and relevant in the midst of the development and complexity of crime in the modern era. Without involving auxiliary disciplines, seeking material truth and providing proper justice in many criminal cases today will be challenging. Criminal procedural law must involve and utilize auxiliary knowledge from various other disciplines. Knowledge of social dynamics, psychology, technology, and other aspects is essential to uncover and understand these increasingly complex crime cases. In other words, assistive science in criminal procedural law is helpful. It becomes essential and relevant amid the modern era's development and complexity of crime. Without involving auxiliary disciplines, seeking material truth and providing proper justice in many criminal cases today will be challenging. In other

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Neuroscience a Science to Help Criminal Law in the Future

Speaking of "Neuroscience," in order to properly read and comprehend the topics covered in this essay, we also need to talk about "Neurolaw." The interdisciplinary topic of neurolaw investigates how legal norms and regulations are impacted by discoveries made in the study of neuroscience. Neurolaw practitioners use a variety of disciplines, including philosophy, social psychology, cognitive neuroscience, criminology, and neuroscience, to address normative as well as descriptive questions about how and when neuroscience should or shouldn't be used in the legal system.

Human moral and legal judgements are centred on choices and actions, therefore it stands to reason that knowledge of the neurological mechanisms underlying human decision-making and action production would have a substantial impact on these judgements. However, the findings of neuroscience research have had comparatively little impact on legal practise, despite the abundance of empirical evidence and public attention it has garnered in recent decades. This article makes the case that conversations on the interaction between neuroscience and the law, which mix together a

[20] Suryanto, *Hukum Acara Pidana* (Zifatama Jawara 2018).[16].

number of distinct topics with varying degrees of significance for our moral and legal decisions, are partly to blame for this. Here, a hierarchical method is used to separate the more and less practical ways that neuroscience data can help with these decisions. Our legal reasoning can be influenced by neuroscientific and other physical perspectives on human behaviour and decision-making. But there are many other ways that this might occur, and far too frequently, the use of neuroscience data is taken for granted when making moral and legal decisions. The intuition of human physicists readily leans towards neural-level explanations rather than mental-level ones. But that does not entail that all brain data is automatically relevant to moral and legal thinking, even if people adopt some form of reductionist physicalism. But neurology can offer circumstantial evidence in favour of reductionist physicalism, which might make us question the existence of free choice. In the end, these advancements might also affect the law and legal profession.[21]

Neurolaw, or applying knowledge of the nervous system to law, is becoming increasingly popular and essential in the modern legal system. One example of the effective use of neurolaw can be seen in the Netherlands, where they have used knowledge from neuroscience in developing juvenile criminal law since 2014.[22] Neuroscience studies have led to a better understanding of how adolescent brains develop and function, including how adolescents make decisions and how their environment influences them. This knowledge has been used in developing juvenile criminal law in the Netherlands to inform their approach to dealing with young offenders. For example, neuroscience has shown that the adolescent brain is still developing, and the parts of the brain responsible for impulse control and good decision-making are not fully mature. This means that youth may

[21] Tuomas K Pernu dan Nadine Elzein, 'From Neuroscience to Law: Bridging the Gap' (2020) 11 Frontiers in Psychology.[1].

[22] Stephan Schleim, 'Real Neurolaw in the Netherlands: The Role of the Developing Brain in the New Adolescent Criminal Law' (2020) 11 Frontiers in Psychology.[1].

not always be able to make good decisions and think ahead about the consequences, making them more vulnerable to criminal behaviour. Given this, Juvenile criminal law in the Netherlands recognizes that juveniles may require a different approach to law than adults. This law was designed to put more emphasis on rehabilitation than punishment, to help youth to learn from their mistakes and develop the skills and understanding they need to make informed decisions. Better in the future.[23]

Advances have significantly influenced the development of neurolaw in medical technology and neuroscience. Modern tools and techniques such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET scan), magnetic resonance imaging (MRI), and epigenetics are critical in understanding brain function and structure, which in turn aids the law in several ways.[24] Brain imaging techniques such as fMRI and PET scans allow us to see brain activity in real-time. For example, fMRI can be used to observe which parts of the brain are active when a person performs a specific task or thinks about a certain thing. This can be very helpful in understanding individual motivations and thought processes, which can be used in legal contexts to help determine a person's intentions or mental capacities. An MRI, on the other hand, provides a very detailed picture of brain structure. This can help understand how specific injuries or medical conditions affect a person's brain function and behaviour. Epigenetics, the study of how our environment and experiences can affect our genetic expression, has enormous potential implications in law. For example, knowledge about how trauma or stress can change our genes and influence our behaviour can be used in defence in legal cases. Each of these technologies and disciplines broadens our understanding of the human brain and behaviour and, in so doing, provides new and valuable tools for law and

[23] *ibid*.

[24] Nicole A Vincent, 'Neurolaw and Direct Brain Interventions' (2014) 8 Criminal Law and Philosophy.[43].

criminal justice systems. Advances in neurolaw depend heavily on these advances in technology and knowledge.

Neurolaw is slowly making its way into legal systems worldwide, but there is also a growing sense of professional and public scepticism about its validity. Layanan deteksi kebohongan berbasis pencitraan saraf disediakan oleh Cephos Corporation di Tyngsboro, Massachusetts, dan No Lie MRI di San Diego, California.[25] Their services are considered a more advanced form of the polygraph test (also known as a "lie test") but are rarely accepted as evidence in courtrooms. This lie-detection method, which relies on brain scans rather than heartbeats, still needs broad support among neuroscientists or the legal community.

Neuroscience involves a variety of systematic experimental and theoretical investigations of the central and peripheral nervous systems of living organisms. The empirical methodology employed by the field of paraneuroscience has evolved from biochemical and genetic analysis of individual nerve cell dynamics and their molecular constituents to perceptual image presentation and motor activity in the brain. Even at the present time, computational modelling has been performed to corroborate this neuroscience. Neuroscience incorporates, in general, all scientific disciplines pertaining to the nervous system.

Psychology, as the scientific study of mental processes, can be considered a subfield of neuroscience, although some mind/body theorists disagree with this; according to them, psychology is the study of mental processes that can be modelled by a variety of abstract principles and theories, such as traditional cognitive and behavioural psychology, and it is unrelated to nerve processes.

Of the billions of brain cells, about 1/10 contains active neurons or nerve cells capable of making up to 20,000 different connections with

[25] Christopher Intagliata, 'Is the MRI Lie Detector Test Reliable?' (*scienceline.org*, 2008) <https://scienceline.org/2008/11/ask-intagliata-lie-detection-fmri-brain-scan/>.

other cells. In neuroscience, six integrated brain systems regulate all human behaviour: the prefrontal cortex, limbic system, cingulate gyros, basal ganglia, temporal lobe, and cerebellum.

Twenty years ago, it would have been inconceivable to peer into the black box of the human psyche with the level of precision that neuroscience has made possible. Advancements in brain imaging and genome science have begun to cast light on the biological roots of aggression and antisocial behaviour. Several people are enthusiastic about neural prediction. This enthusiasm is founded on two premises:

1. The belief that individual biological measures have intrinsic reliability and validity that non-biological tools do not;
2. Humans can make decisions about specific individuals, which is the goal of criminal law.

Unfortunately, both assumptions can fail when it comes to something as complex and messy as human behaviour. Brain images and DNA sequences may one day help predict individual behaviour. However, today, neuroscience tools need to be more crude and human understanding of the brain is too imperfect.[26]

Behavioural testing and neuroimaging findings present promising modalities that have the potential to enhance the accuracy of forecasting human behaviour. The utilisation of these techniques in the field of criminology would yield significant advantages in the determination of appropriate durations for criminal sentences, as well as in the evaluation of the risk associated with retaining or releasing offenders, by leveraging predictive models of future criminal behaviour. The utilisation of these tools has the potential to facilitate the reduction of recidivism rates and offer insights into the necessity for individualised rehabilitation efforts

The following are some of the technologies in brain imaging that are being developed in the world today:[27]

[26] Joshua W. Buckholtz, 'Neuroprediction and Crime Center for Law, Brain & Behavior' (*clbb.mgh.harvard.edu*, 2012).

[27] Fadiyah (n 6).

1. EEG (Electroencephalography)

   EEG is a tool used to measure electrical activity in the brain by recording from electrodes placed on the scalp. EEG is often used for experiments because the process is non-invasive for research subjects and can also detect changes in electrical activity in the brain at the millisecond level. This EEG can show brain activity in certain psychological states, such as anxiety, fear, sleepiness and others. EEG is also helpful in diagnosing seizures and medical problems regarding excess or under activity in certain parts of the brain.

2. CT (Computed Tomography)

   A CT scan is a tool issued in 1972 a CAT scan that detects brain conditions using X-rays from an X-ray tube but eliminates much of the superimposition of radiographs by demonstrating the body in a series of sections. The images produced from these scans provide detailed information about brain tissue and its structure. Usually, this CT scan is used to detect the brain condition of people with stroke and vascular dementia.

3. PET (Positron et al.)

   PET is a technology that measures glucose levels in the brain to describe where nerve firing occurs. The way to use it is by using a tracer substance injected into the blood when the brain becomes active, and then this blood (blood containing the tracer) is sent to deliver oxygen. The result is to create visible dots, which the detector will pick up and use to create video images of the brain performing certain tasks. The drawback of this PET technology is that PET can only find general areas of brain activity and not more specific locations; it is expensive and invasive. PET is commonly used to diagnose vital body functions, such as blood flow, oxygen use and blood sugar metabolism and for Alzheimer's.

4. MRI/fMRI (Magnetic et al./ Functional Magnetic Resonance Imaging)

   The definition of MRI / fMRI quoted from PsychCentral is a brain scan technology that uses the scanner's magnetic field to influence the magnetic nucleus of the hydrogen atom so that it can be measured and converted into an image. When brain areas are more active, brain areas consume more oxygen, and to meet the

increased demand, blood flow increases to active areas. MRI and fMRI differ because MRI displays anatomical structures, whereas fMRI measures metabolic function. fMRI is typically used to generate activity maps that show which parts of the brain are involved in specific mental processes.

5. MEG (Magnetoencephalography)

   This technology usually measures the magnetic field generated by electrical activity in the brain through a sensitive device known as SQUID. This measurement is commonly used in research and clinical settings. The function or use of the MRG is to assist surgeons in localizing a pathology, assisting researchers in determining the function of various parts of the brain, neurofeedback and much more.

6. TMS (Transcranial et al.)

   TMS is a first-line recommendation for patients with depressive problems who have failed at least one antidepressant. This TMS works by using electricity to produce a magnetic field that is strong enough but only for a very short time, whose main task is to work by inducing an electric current into the brain by using a pulsed magnetic field generated on the outside of the brain near the scalp.

7. Micro TC (Microtomography)

   Micro TC is a 3D imaging technology that uses X-rays to see the inside of an object, slice by slice. Micro TC is similar to a CT scan or CAT. However, the resolution scale obtained is small, with an increased resolution with pixel sizes as small as 100 nanometers and objects that can be scanned with diameters up to 200 millimetres.

The latest brain imaging technologies, such as those listed above, offer a window into human brain function with a level of detail never seen before. In the context of criminal justice, the potential uses of this technology are enormous. First, EEG, with its ability to detect electrical activity in the brain at the millisecond level, can be used to understand the brain's response to various stimuli, including responses to criminal events or the truth and lies of a person's account. This, in

turn, can inform more in-depth psychological and neuropsychological forensic analysis of offender motives and behavior. CT and Micro TC, both technologies that utilize X-rays to produce detailed images of brain structures, can be used in criminal justice to detect possible injuries or medical conditions that might affect a person's behavior, thus providing important medical context in legal cases. PET, which measures glucose levels in the brain, and MRI/FMRI, which measures metabolic activity and brain structure, can be used to create detailed maps of brain activity during various cognitive tasks. These technologies can be very useful in understanding neurological disorders or states that may contribute to criminal behavior, as well as in proving or disproving claims of certain mental or cognitive conditions in court. MEG, with its ability to measure magnetic fields generated by the brain's electrical activity, can also be a useful tool in forensic neurological research, aiding in a more in-depth mapping of brain function and an understanding of how certain brain activities may be related to criminal behavior. TMS, on the other hand, offers a potential avenue for therapy or intervention, with the potential to be used in the rehabilitation or treatment of individuals who have been found guilty of a crime, especially those suffering from underlying mental health issues. Overall, these brain imaging technologies have the potential to revolutionize the way we understand and treat crime and criminal justice by enabling a more in-depth and nuanced understanding of the human brain and how it influences behavior.[28]

The concept of brain imaging technology today is highly advanced, with various methods that can understand the structure and function of the brain in great detail. In the domain of neuroscience, these technologies open the door to a deeper understanding of how the brain influences human behavior, including propensity towards criminal activities. Neuroscience now understands that human behavior is the result of complex interactions between brain structure, function, and environmental experiences. Brain imaging technologies such as EEG, CT, PET, MRI/fMRI, MEG, TMS, and micro-TC are becoming crucial tools in exploring

[28] Walter Glannon, 'The Limitations and Potential of Neuroimaging in the Criminal Law' (2014) 18 The Journal of Ethics 153.

and understanding these dynamics.[29] For example, fMRI and PET can be used to understand the areas of the brain that are active during certain activities, while EEG and MEG can provide information on the real-time dynamics of brain activity. As it relates to the future of criminal law, these technologies have the potential to be very valuable "tools". First, they can be used in judicial proceedings to help prove or disprove claims about the defendant's mental state at the time of the crime. For example, fMRI can be used to assess the veracity of a person's testimony or even identify potential lies. Furthermore, these technologies can be used in offender rehabilitation. For example, TMS, which is already used to treat depression, could be further developed to aid in the rehabilitation of individuals who have mental health issues that affect their criminal behavior.

So far, the implementation of neuroscience technology in the criminal justice system is still in its early stages and has not yet fully spread across the globe.[30] However, some countries have begun to utilize or at least explore the use of this technology. In the United States, there have been several initiatives to incorporate neuroscience evidence into the courtroom. The use of brain scans, such as fMRI, has been used in some cases to try to prove the defendant's mental state or to assess the potential risk of recidivism. In recent years, lawyers have started using evidence from neuroscience research to defend their clients, especially in cases where mental state or brain damage is a relevant factor.[31] India has also seen the introduction of neuroscience technology to their justice system, particularly with the use of neuro-based lie detectors (such as the Brain Electrical Oscillations Signature) that aim to determine whether someone is lying based on their brain responses.[32] However, these techniques have sparked extensive ethical debates and are still in the process

[29] Scott Makeig and others, 'Linking Brain, Mind and Behavior' (2009) 73 International Journal of Psychophysiology.[95].

[30] John B Meixner, 'Applications of Neuroscience in Criminal Law: Legal and Methodological Issues' (2014) 15 Current Neurology and Neuroscience Reports.[513].

[31] Davide Rigoni, Luca Sammicheli dan Giuseppe Sartori, 'Looking for the Right Intention: Can Neuroscience Benefit from the Law?' (2015) 9 Frontiers in Human Neuroscience.[1].

[32] Sidhartha Sekhar Dash Assistant Professor-II, Harish Ch Padhi and Biswadeep Das Assistant Professor, 'Place of Neuroscience in Indian Juvenile Justice' (2021) 5 Linguistics and Culture Review.[948].

of further testing and evaluation. In several European countries, there are ongoing initiatives and research projects to explore the potential and limitations of using neuroscience technology in the justice system.[33] This includes the development of new tools and methods, as well as discussions and debates regarding the ethical and legal implications of using these technologies.

Indonesia's criminal justice system has, so far, remained closely tied to traditional methodologies in dealing with criminal cases, namely through the collection of physical evidence and testimonies. Long-established legal procedures, including initial police investigations, case formation, and court trials, are commonplace in the country's criminal justice structure. The global context is witnessing a profound scientific and technological revolution, which is progressively beginning to affect legal systems in various parts of the world. In this context, Indonesia is potentially no exception to adopting these innovations, particularly in the field of neuroscience, in order to modernize its criminal justice system. With the rapid pace of technological and scientific development, the possibility for Indonesia to start considering the integration of neuroscience technologies in the criminal justice process cannot be ignored. Particular emphasis will likely be placed on the use of brain imaging technology and other neuroscience methods that can play a crucial role in uncovering and verifying the mental state of the accused at the time of the crime. This can not only help in establishing or disproving claims of mental state but also in designing more effective and evidence-based rehabilitation programs for offenders by understanding the neurobiological basis of their behavior. Overall, the integration of neuroscience technology into Indonesia's criminal justice system could pave the way for a more scientific, humane, and evidence-based approach to dealing with crime, thus creating a more just and equitable system.

Neuro Prediction and Artificial Intelligence a Development of Neuroscience

Recently, there has been an increased utilization of artificial intelligence

[33] Sjors LTJ Ligthart, 'Coercive Neuroimaging, Criminal Law, and Privacy: A European Perspective' (2019) 6 Journal of Law and the Biosciences.[296].

(AI) in the medical imaging domain, particularly in the context of molecular imaging related to the central nervous system. This field of study focuses on exploring how computers and robots can achieve intelligence.[34] This includes the development of neuroprotection and artificial intelligence, also known as AI Neuroprediction. With neuroimaging techniques, doctors can detect damage to the human brain. This is inseparable from the technology that is developing rapidly in the era of revolution 4.0 and society 5.0 now and in the future, so knowledgeable doctors can use this neuroimaging to visualize brain scan results, determine what is in the patient's brain, and determine the diagnosis and treatment strategy.[35]

Among the latest technological advances that can be utilized in the field of law to catch up or narrow the lag of events, the field of law can apply artificial intelligence. The fact is that artificial intelligence is now being used in every aspect of society; thanks to artificial intelligence, people's daily work and life have become more accessible.[36] Examples of artificial intelligence being used by the Australian government, for example, to improve customer service at the Australian Tax Office. This saves citizens the trouble of visiting government offices if they have questions. This program has proven to be effective because it minimizes bureaucracy. After one year of operation, the program can react to more than 500 different types of queries and participate in 1.5 million discussions, 81% of which can be successfully handled by artificial intelligence.[37]

The positive results of applying artificial intelligence to various disciplines, including business and healthcare, naturally become a driving force for more applications of artificial intelligence that benefit people. Therefore, if humans want

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[34] Amanda J Boyle and others, 'Artificial Intelligence for Molecular Neuroimaging' (2021) 9 Annals of Translational Medicine.[1].

[35] Allan McCay and Jeanette Kennett, 'Neuroscience and Punishment: From Theory to Practice' (2021) 14 Neuroethics.[269].

[36] Philipp Kellmeyer, 'Artificial Intelligence in Basic and Clinical Neuroscience: Opportunities and Ethical Challenges' (2021) 25 Neuroforum.[241].

[37] AkbarRahmadhiyanto,'PerspektifIslamMengenaiPenerapanArtificialIntelegence'(*kompasiana.com*, 2019) <https://www.kompasiana.com/akbarrahmadhiyanto/5de4e41ed541df69fe677282/perpektif-islam-mengenai-penerapan-artificial-intelegence>.

to avoid the law being left behind regarding technical and societal progress, humans need to start using artificial intelligence in law, especially in Indonesian national law.

The prospective utilisation of neuroimaging in conjunction with artificial intelligence (AI) The utilisation of neuroprediction for the enhancement of risk assessment and the prediction of future violent behaviour has garnered significant attention due to recent advancements in brain imaging technology and the increasing involvement of artificial intelligence. These methodologies might be conceptualised as "neurocognitive decoding" techniques, which integrate statistical machine learning approaches with neuroimaging data to unveil insights about the brain and cognition. The investigation of brain reading is frequently conducted within the realm of visual perception, with the objective of elucidating the mechanisms by which the brain encodes and represents events. In recent studies, researchers have achieved notable progress in training artificial neural networks to engage in visual picture reconstruction of the brain, decipher the visual content of dreams, and employ artificial intelligence to understand the visual perceptions of the brain. The approach referred to as "neuro-prediction" utilises anatomical or functional brain characteristics to forecast prognosis, treatment outcomes, and predictive behaviour within the field of medicine.[38] While these are promising findings for the future, the method still exhibits many flaws and limitations that make it unlikely that a full-fledged "mind-reading technique" will emerge shortly.

> The initial stage in the development of predictive artificial intelligence models utilising neuroimaging data involves doing research that employs functional magnetic resonance imaging (fMRI) data to forecast the behaviours of individuals with criminal tendencies or a history of recidivism. According to a study conducted by Delfin, there exists potential for enhancing the accuracy of recidivism prediction in the field of forensic psychiatry by the integration of neuroimaging data into an artificial

[38] Tortora and others (n 7).

intelligence-based risk assessment model.[39] To summarise, preliminary discoveries in the field of artificial intelligence neuroprotection research have shown encouraging outcomes. Nevertheless, the potential use of artificial intelligence and "neuroimaging-based deception detection" in the realm of forensic psychiatry gives rise to a multitude of ethical and legal concerns, necessitating a prudent approach by the criminal justice domain towards its prospective implementation. Notwithstanding the aforementioned prospects pertaining to the potential application of Neuroprediction AI, it is imperative to acknowledge certain constraints.

According to the Mind Research Network located in Albuquerque, brain scans have the potential to forecast the probability of recidivism among those who have been incarcerated. The research conducted by the Mind Research Network pertains to the examination of impulsive and antisocial behaviour, with a specific emphasis on the anterior cingulate cortex (ACC). This particular region of the brain is closely linked to the regulation of behaviour and impulsivity. The present study examined a sample of 96 adult male offenders, ranging in age from 20 to 52, who willingly consented to participate in a research investigation. A cellular magnetic resonance imaging (MRI) device was employed to gather neuroimaging data during the administration of mental exams to incarcerated participants. The study cohort was monitored for a maximum duration of four years subsequent to their release from incarceration. The anterior cingulate cortex of the brain is linked to processes such as error detection, monitoring of conflicting information, selection of appropriate responses, and acquisition of avoidance behaviours. Individuals who have incurred injury to these specific regions of the brain have been demonstrated to exhibit alterations in shyness, apathy, and aggressiveness. Individuals who have experienced injury to the anterior cingulate cortex (ACC) have been categorised within the framework of "acquired psychopathic personality." The researchers discovered that incarcerated individuals exhibiting comparatively diminished

[39] Carl Delfin and others, 'Prediction of Recidivism in a Long-Term Followup of Forensic Psychiatric Patients: Incremental Effects of Neuroimaging Data' (2019) 14 PLoS ONE.[1].

levels of anterior cingulate activation were twice as prone to engage in criminal behaviour again. Individuals who exhibited precipitated behaviour demonstrated a higher likelihood of having reduced activity in the anterior cingulate cortex compared to those individuals with a higher level of functioning in the ACC. The implications of these findings have great importance for the future of our society's approach to criminal justice and individuals involved in illegal activities. This study not only offers a framework for predicting recidivism among criminals, but also presents a potential avenue for guiding offenders towards more efficacious targeted interventions aimed at mitigating the likelihood of future criminal behaviour. The findings of this study indicate a neural prediction approach that exhibits considerable promise and holds significant practical implications for the field of legal systems. Moreover, it offers a means to guide offenders towards more efficacious and focused therapeutic interventions aimed at mitigating the likelihood of subsequent engagement in criminal behaviour. The findings of this study indicate a neural prediction approach that shows promise and has significant practical implications within the context of judicial systems. Moreover, it offers a means to guide offenders towards more efficacious and focused therapeutic interventions aimed at mitigating the likelihood of subsequent engagement in criminal behaviour. The findings of this study indicate a neural prediction approach that shows promise and has significant practical implications within judicial systems.[40]

The utilisation of brain scans during the trial phase of sentencing has witnessed a notable surge in the United States, as evidenced by a twofold increase in the proportion of cases containing neuroscientific evidence between 2006 and 2009. Neuroimaging was employed in two separate instances in California and New York, resulting in the defendants successfully mitigating their charges from homicide to first-degree murder. In each instance, brain scans were provided as evidence, demonstrating compromised neurological functioning, with the intention of mitigating the individuals' culpability in relation to the committed offence. In the

[40] Eyal Aharoni and others, 'Neuroprediction: Brain Scans Foretell Criminal Behavior' (2013) 110 Proceedings of the National Academy of Sciences of the United States of America.[1].

legal case of Harrington v. State of Iowa in 2003, neuroimaging techniques were employed as evidentiary support for the defence. Nevertheless, in the Harrington v. State of Iowa case, brain scans were exclusively presented to the judges rather than the entire judgement panel.[41]

The judicial system in Mumbai, India has adopted a proactive strategy in integrating neuroscience into criminal convictions, so demonstrating a heightened level of engagement in this field. In the year 2008, a murder conviction was secured against an Indian woman on the basis of compelling circumstantial evidence, which notably included a brain scan indicating her culpability.[42]

There exists a diverse range of artificial intelligence applications that have been showcased in the field of neuroimaging. It is plausible to anticipate a rise in their utilisation as the technology advances further. The utilisation of artificial intelligence for the detection of essential neurological diseases shows potential in addressing the escalating quantities of medical imaging data and delivering accurate diagnoses. The increasing integration of artificial intelligence in the field of medicine necessitates a comprehensive understanding among practitioners regarding its present and forthcoming applications.[43]

Conclusion

Criminal law enforcement cannot be carried out only by referring to one scientific discipline because this relates to whether or not the legal objectives of justice, certainty and benefit can be realized, which Gustav Radbruch called the "Three Basic Values of Law". Development of brain imaging tools such as EEG (Electroencephalography), CT (Computed Tomography), PET (Positron et al.), MRI/fMRI (Magnetic et al./Functional Magnetic Resonance Imaging), MEG

[41] Darby Aono, Gideon Yaffe and Hedy Kober, 'Neuroscientific Evidence in the Courtroom: A Review' (2019) 4 Cognitive Research: Principles and Implications.[1].

[42] Nigel Eastman and Colin Campbell, 'Neuroscience and Legal Determination of Criminal Responsibility' (2006) 7 Nature Reviews Neuroscience 2006.[311].

[43] Robert Monsour and others, 'Neuroimaging in the Era of Artificial Intelligence: Current Applications' (2022) 39 Federal Practitioner.[14].

(Magnetoencephalography), TMS (Transcranial et al.), Micro TC (Microtomography) during the development of the industrial revolution 4.0 and new society 5.0 has created a tool that combines neuroprotection and artificial intelligence or is called AI Neuroprediction to improve risk assessment and behaviour prediction of future criminal acts has received attention in light of recent developments in brain imaging and the expanding role of artificial intelligence. This technique can be considered a "brain reading" or "mind reading" technique, combining statistical machine learning methods with neuroimaging data to reveal information about the human brain/mind, this has been tried in America and India. Indeed, the use of AI Neuroprediction still has many pros, cons, and weaknesses. However, the possibility of using AI Neuroprediction in forensic psychiatry in criminal procedural law is intriguing to note, even though it can raise some ethical and legal problems.

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