NEUROTECHNOLOGY AND THE LAW: LEGAL CONSIDERATIONS FOR PRIVACY, AUTONOMY, AND LIABILITY

AZIZ YASSIN AZIZ
Place of work: Department of Law, Faculty of Law Political Science and Management, Soran University
Residence: Iraq, Erbil, Soran
Email: aziz.aziz@soran.edu.iq
Mobile: 009647504609339

Abstract:
The lightning-fast advancements in neurotechnology offer unparalleled potential for treating neurological disorders and enhancing cognitive abilities. However, these breakthroughs come with major legal and ethical dilemmas that demand prompt and responsible attention. The research problem of this article is identifying and addressing the legal considerations surrounding the use of neurotechnology, particularly with regard to privacy, autonomy, and liability. The article is structured into five major sections, which delve into the evolution of neurotechnology, the expanding applications of neurotechnology, the future of privacy in a neurotechnological world, ethical concerns related to neurotechnology's impact on personal autonomy, and liability considerations in the advancement of neurotechnology. Through adopting a qualitative, analytical and interdisciplinary method, the conclusion of the study emphasizes the significance and potential of neurotechnology in treating chronic diseases, while underscoring the urgent need for a comprehensive legal framework to safeguard individuals' rights.
Key words*: neurotechnology, privacy, neurological disorders, liability, personal autonomy, mental augmentation.*

1. INTRODUCTION:

Neurotechnology, which utilizes technology to interface with the brain and nervous system, is rapidly advancing and has significant implications for individuals' privacy. Basically, advancements in neurotechnology include brain implants, brain-computer interfaces (BCIs) and other devices that can record or stimulate neural activity. While these technologies offer exciting potential for medical treatments, education, and entertainment, they also raise concerns about privacy, surveillance, and the potential for misuse. For example, the use of neurotechnology for surveillance or to manipulate individuals' thoughts and behavior could have serious ethical and legal implications. Additionally, the assortment and taking advantage of sensitive brain data raises questions about data privacy and informed consent in many cases where individuals free will may severely suffer from unfair practices and prejudices related to financial and otherwise transactions. Therefore, it is important to strike a balance between the progress of neurotechnology and legal compliance to protect individuals' privacy, autonomy augmentation and legal liability. This requires to contemplate the ethical and legal ramifications of neurotechnology and guarantee its employment is responsible and advantageous.

As neurotechnology continues to advance at an unprecedented pace, it has the potential to revolutionize the way we diagnose and treat neurological disorders, as well as enhance our cognitive and physical abilities. However, the use of neurotechnology also brings with it significant concerns around privacy and security. From brain implants to brain-computer interfaces and other devices, these technologies have the ability to record, monitor, and even manipulate our brain activity, raising concerns about the potential misuse of this sensitive information. As such, it is essential that we take steps to safeguard individuals' privacy and ensure that these technologies are developed and used responsibly.

This article is designed to provide a thorough and in-depth analysis of the current state of neurotechnology and the complex ethical and legal considerations that come along with its development and use. It seeks to examine the potential benefits of neurotechnology, including its ability to improve medical treatments and enhance human capabilities, while also addressing the potential risks and drawbacks associated with this rapidly evolving field, such as privacy concerns and the possibility of misuse or abuse. Moreover, the research seeks to explore the regulatory landscape of neurotechnology, aiming to identify ways to reconcile progress in this area with the corresponding ethical and legal responsibilities. The discussions will likewise cover the necessity for ethical guidelines and responsible research practices, as well as the significance and essentiality of regulation and superintendence to guarantee that neurotechnology is developed and implemented in a safe and ethical manner especially in connection with private law instruments. From this perspective, the article aims to provide a comprehensive and balanced perspective on the current state of neurotechnology and its future direction in terms of ethics and regulations.

The article begins by providing an overview of the types of neurotechnology currently available, including brain-computer interfaces, neural implants, and brain stimulation devices. It then explores the potential benefits and risks of these technologies, such as improved medical treatments, but also the risk of surveillance, manipulation, and discrimination. The article also discusses the current legal landscape surrounding neurotechnology and privacy, including data privacy laws, augmentation, responsibility and relevant ethical considerations. According to the author's point of view, the current legal frameworks may not be adequate to tackle the exceptional challenges presented by neurotechnology, and that new regulations and guidelines are needed to protect individuals' rights while allowing for the responsible development and use of these technologies. The article concludes by providing recommendations for policymakers, researchers, and other stakeholders on how to approach the ethical and legal implications of neurotechnology. These recommendations include promoting transparency and collaboration, developing ethical guidelines, and engaging with stakeholders to ensure that the development and use of neurotechnology is responsible and beneficial.

2. The Evolution of Neurotechnology: From Concept to Real-World Applications

Neurotechnologies are cutting-edge technologies that have the capability to directly interact with the brain or nervous system through reading or writing signals.[1] Neurotechnology which is a field that focuses on developing systems that can manipulate neural activity by injecting signals into the nervous system, typically by applying voltages across neural tissues,[2] has the potential to greatly impact privacy in many ways.[3] In order to fully comprehend the implications of neurotechnology on privacy, it is relevant to explore its definition, historical development, and diverse applications. By understanding the definition of neurotechnology, one can gain insight into the fundamental concepts that underpin the field and affect the legal profession. This will particularly set the stage to shed light on the different ways in which neurotechnology may impact privacy, such as through the collection and analysis of sensitive personal information.

Further, examining the historical development of neurotechnology can provide a valuable perspective on how the field has evolved over time, as well as how it has been used in different contexts. This can be specifically useful in understanding the potential risks and benefits associated with the use of neurotechnology, and how these may vary across different applications and use cases. Finally, exploring the diverse applications of neurotechnology would secure insights into the specific ways in which it may impact privacy. For example, the use of neurotechnology in the workplace may raise concerns around employee monitoring, while its use in healthcare may involve the collection and analysis of sensitive medical data. Accordingly, through delving into these key aspects of

[1] Allan McCay, Horizon Report for The Law Society Neurotechnology; Law and the Legal Profession (2022) available at https://www.lawsociety.org.uk/ pdf, p,9. [accessed on 21, 3, 2023].

[2] Elliot S. Krames, P. Hunter Peckham, Ali R. Rezai, eds, *Neuromodulation 2 Volume Set*, (UK: First Edition, Academic Press, 2009), p, 229.

[3] Elisabeth Hildt, Imre Brad, *Ethical Dimensions of Commercial and DIY Neurotechnologies,* (Netherlands: First Edition, Elsevier Science, 2020), p, 242.

neurotechnology, we can gain a more comprehensive understanding of the implications of this emerging field on privacy, and work towards developing appropriate policies and regulations to mitigate potential risks and promote responsible use.

2.1. The Interface of Brain and Technology: Understanding Neurotechnology

Neurotechnology, the study and application of techniques that enable direct communication between the human brain and machines, is a rapidly evolving field that has generated considerable interest and controversy. While the prospect of connecting the human brain directly to machines raises exciting possibilities for augmenting human capabilities, it also poses ethical and social dilemmas that require careful consideration. Neurotechnology pertains to a set of techniques and instruments that enable a direct connection between technical components and the nervous system. These components encompass electrodes, computers, and sophisticated prostheses, and they serve the purpose of either recording signals from the brain and transforming them into technical control commands, or influencing brain activity through the utilization of electrical or optical stimuli.[4]

Initially, neurotechnology refers to any artificial method used to interact with the brain and nervous system with the aim of investigating, accessing, and manipulating the structure and function of neural systems. This includes brain research itself, electronic devices designed to repair or substitute brain functions, neuromodulation devices for treating mental illnesses, and the development of artificial synapses and neuronal networks for brain-computer interfaces and the advancement of artificial intelligence. The progress made in understanding the brain stems from the interplay between neuroscience and technology, which in turn affects human nature. In this context, various tools and technologies, including drugs, stem cells, physical therapy, surgery, genetic manipulation, behavior, education, and neurotechnological devices, have been utilized to tackle nervous system disorders.[5]

Within this description, neurotechnological instruments would fall into two categories: 'assessment neurotechnologies and interventional neurotechnologies'. As W. Johnson argues, through adopting this comprehension, the term 'neurotechnology' is limited to a more specific concept, concentrating on innovations that directly affect human neural systems. Also, this comprehension allows policymakers to customize regulations and policies to assess the advantages and drawbacks of products like spinal cord stimulators and brain-machine interfaces (BMIs) more efficiently, instead of grouping them with unrelated products like mobile phone apps.[6] Neurotechnologies which are used for evaluation consist of different types of techniques such as neuroimaging, encephalography, thermography, genetic/genomic and proteomic technologies, and tests for neural biomarkers. However, interventional neurotechnologies encompass a diverse range of tools and techniques, including neuro and psychopharmacological agents, innovative pharmaceuticals, transcranial and in-dwelling brain stimulation devices, peripheral neural stimulators, neural cell, tissue and genetic implants and transplants, in-dwelling micro and sub microelectronics, and nerve-and brain-machine interfacing neuroprosthetic systems.[7]

On the other hand, neurotechnology-based interventions can be highly effective in treating brain disorders, often leading to significant improvements in quality of life in addition to traditional pharmaceutical treatments. However, it is important to recognize that such interventions can result in changes to the brain and its functions, whether intended or unintended; there are instances where

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[4] Oliver Müller, Stefan Rotter, "Neurotechnology: Current Developments and Ethical Issues" [2017, 11, 93], *Frontiers in Systems Neuroscience*, p, 1.

[5] Bowman Diana M, et al, "The Neurotechnology and Society Interface: Responsible Innovation in an International Context" [2018, 5, No, 1] *Journal of Responsible Innovation*, p,8.

[6] Walter G. Johnson, "Catching up with Convergence: Strategies for Bringing Together the Fragmented Regulatory Governance of Brain-Machine Interfaces in the United States" [2021, 30, No. 1], *Annals of Health Law*, p, 181.

[7] James Giordano, ed. *Neurotechnology: Premises, Potential, and Problems*. (USA: First Edition, Taylor & Francis, 2012), p, 4.

interventions can modify a patient's personality and character, either intentionally as a desired outcome or unintentionally as an undesirable side effect. While changes in personality may be intended in the treatment of certain affective disorders, it is essential to consider the risks and ethical implications of such interventions. How much alteration of cognitive and emotional functioning is acceptable? Does the use of neuroprocessing that autonomously interpret or alter brain activity affect our sense of legal responsibility? Furthermore, do we remain the same person after such interventions or are we transformed into someone else entirely? These are complex ethical questions that require careful consideration and examination.[8]

Obviously, BCIs are at the core of neurotechnology and denote to the immediate and direct connections established in real-time between the human brain and a computing device,[9] and systems that interpret the electrical signals generated by the brain, which can then be used to operate external devices like computer cursors, internet browsers, robotic arms, switches, and prosthetic limbs. These devices are capable of reading the signals generated by the brain and converting them into communication and control signals. BCIs are designed to bypass the usual neuromuscular pathways in the body and instead use the brain's signals to operate the external devices. The signals generated by the brain are processed and analyzed by a computer through signal processing and pattern recognition techniques to enable effective communication and control.[10] Additionally, BCIs have the ability to either extract brain data or manipulate brain activity, and they can be invasive, inserted inside a person's skull, or non-invasive, like a helmet placed over the head. Nevertheless, both types of neurotechnology exhibit particular loopholes in regulations, which subsequently lead to gaps in safeguarding human rights.[11]

Broadly speaking, the term ‘neurotechnology' encompasses any technology that has a direct or indirect impact on human neurology and psychology. This definition is inclusive of mobile phone applications and wearable devices, which may not directly interact with the nervous system, but have the potential to bring about some degree of change to neural circuitry. The breadth of this definition raises important social and regulatory concerns that are yet to be resolved. However, this all-encompassing view of neurotechnologies may be too wide-ranging, as it fails to distinguish between numerous existing technologies and a smaller group of emerging and game-changing innovations.[12]

2.2. History of Neurotechnology: From Richard Caton to Brain-Computer Interfaces

The simultaneous growth of the scientific community in the second half of 1800s can be partially credited to the creation and utilization of new instruments that enhanced the precision of research and analysis, allowed for the manipulation of nature, and influenced humanity. Consequently, technology became the main tool of contemporary science, allowing for more intricate and sophisticated observation and experimentation, which led to the accumulation of more knowledge and the formation of novel theories.[13] In fact, Paul Broca could be regarded as the pioneering figure who initiated and laid the foundation for the basic and unsophisticated attempts that led to the study of the brain. In April 1861 Louis Victor Leborgne passed away in Paris, after living for 21 years with the inability to speak, except for the utterance of the syllable ‘tan’. Following his death, physician and anatomist Broca examined Leborgne's brain and found an injury on the front part of the left

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[8] Müller, Rotter. “Neurotechnology”, Op.cit, p, 2.

[9] L. Syd M. Johnson, Karen S. Rommelfanger, eds. *The Routledge Handbook of Neuroethics*. (UK: First Edition, Routledge, 2018), p, 325.

[10] Nadine Liv, “Neurolaw: Brain-Computer Interfaces,” [2021, 13, No. 1], Thomas Journal of Law and Public Policy, p, 329.

[11] Rafael Yuste, Jared Genser and Stephanie Herrmann, “It’s Time for Neuro-Rights,” [2021, 18], *Horizons*, p,155.

[12] Johnson, "Catching up with Convergence” Op. cit., p, 181.

[13] Giordano, “Neurotechnology,” Op. cit. p, 1.

hemisphere. Later on, further autopsies conducted by Broca on patients with similar speech loss revealed similar lesions in the same area. These findings were groundbreaking in demonstrating that particular domains of the brain are accountable for functions such as speech production. Thus, Broca's work provided the foundation for the field of neurotechnology and neuroscience, which emerged and gained traction over a century later.[14] Putting it more specifically, the development of neurotechnology can be traced back to the mid of 1870s, with the discovery of the electrical activity of the brain by the British physiologist Richard Caton who conducted a series of experimentations aimed at measuring the brains of living animals which exhibit a highly bursty electrical output.[15] Through surgical procedures that would expose the brain parts of a couple of animals including monkeys, dogs, and rabbits, and, he employed wires to establish a connection between their brains and an instrument that gauged electrical current. In actuality, this groundbreaking work was significant as it expounded the initial evidence that the brain's functions could be accessed directly, without the need for traditional methods such as sounds, gestures, or other conventional approaches.[16]

On the other hand, it was not until the mid-20th century that neurotechnology began to advance rapidly with the invention of the EEG (electroencephalogram), when in 1924, Hans Berger, who was a professor of psychiatry and neurology at Jena, successfully recorded electrical waves from the human brain. Berger's main goal was to gain a better understanding of the physiological connections between mental functions and the brain, and he discovered that he could record brain waves by using metal electrodes placed on the skull.[17] Initially, the creation was met with a great deal of skepticism by medical and scientific organizations in Germany before gaining international recognition in 1937. Once the electroencephalogram (EEG) was developed, it became a widely used tool on a global scale to diagnose brain abnormalities. Additionally, following its development, numerous researchers utilized it to showcase epilepsy.[18]

Furthermore, during the 1940s, the field of neuroscience underwent a significant shift thanks to the pioneering work of Warren McCulloch and Walter Pitts, who jointly developed a computational model for neural communication networks, which they called threshold logic. This model was based on mathematical principles and algorithms, and it proved to be a game-changer for neural network connection research. Henceforth, the threshold logic model opened up the possibility of dividing the study of the brain into two distinct approaches. One of these approaches is centered around the biological processes that occur in the brain and seeks to comprehend the intricate neural networks that form the basis of behavior and cognition. Meanwhile, the other approach explored the utilizing of neural networks in artificial intelligence, with researchers seeking to develop machines that could replicate the learning and decision-making processes of the human brain. Also, around the same time, in 1948, the first attempts to build artificial neural networks using Hebb's principles of neural plasticity began to emerge, setting the stage for the development of modern machine learning algorithms.

In the realm of technological innovation, humanity has encountered a new aspect of scientific evolution known as Brain-Computer Interfaces (BCI). The development of BCI systems dates back to the mid-1960s, when the US Department of Defense initiated research aimed at reducing the

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[14] Open Mind BVA, Four Great Landmarks in the History of Neurotechnology: https://www.bbvaopenmind.com/en/science/bioscience/four-great-landmarks-in-the-history-of-neurotechnology/ (12 December 2019), [accessed on 4/2/2023].

[15] Stanley Finger, *Minds behind the Brain: A History of the Pioneers and their Discoveries*. (UK: Frist Edition, Oxford University Press, 2000), p, 253.

[16] Giordano, "Neurotechnology," Op. cit. p, 146.

[17] Finger, *Minds Behind the Brain*, Op. cit. p, 253.

[18] Giordano, "Neurotechnology," Op. cit. p, 147.

cognitive workload of fighter pilots by enabling them to interact with their aircraft's computer. In reality, the project was discontinued due to the lack of advanced technology required to support its goals. Nevertheless, it paved the way for further research programs, and today, researchers have created numerous prototypes that can record the user's brain activity, including NeuroSky, EPOC, P300, and others.[19] The first BCI was developed in 1964 when Dr. Grey Walter implanted electrodes into the motor regions of a patient's brain and connected them to a slide projector. The patient was asked to move forward slides at their own discretion, but in reality, it was the amplified signals from the implanted electrodes that advanced the slides. This was the first instance of controlling an external device without movement. Following this, BCI research has primarily focused on designing control and communication instruments and methods available and for persons afflicted with severe medical conditions such as total paralysis or locked-in syndrome. The goal has ever since been to provide such individuals with critical facilities and gadgets. As BCI technology has progressed, it has become more accessible to people with less severe disabilities, thereby creating new possibilities for treating conditions such as stroke, autism, and other disorders.[20]

In 1990, a tech company called Neurotechnologija was established in Vilnius, Lithuania, after several years of research and work in the field. The company's primary concept involved utilizing neural networks for various applications, including biometric person identification, computer vision, robotics, and artificial intelligence. Related to this, neuromorphic computing, also known as neuromorphic engineering or neuromorphic systems, was first proposed by Mead in 1990. It is an approach that seeks to model biological nervous systems and brains, with the ultimate goal of building chips and computers that resemble brain structures and enable the development of Artificial Intelligence (AI) systems. The aim is to understand the biological mechanisms by which neurons collectively react to stimuli. With the significant increase in computer power and the growing availability of digital data, as well as the development of "deep learning" systems that mimic neuronal layers in the brain, there is potential for AI to become a reality in our society through technology convergence.[21]

Neurotechnologija declared on April 14, 2008 that it would alter its official company name to Neurotechnology. Throughout the years, Neurotechnology has launched more than 40 products and advancements in personal identification, credentials, and validating corroborations. Presently, Neurotechnology's algorithms and software development technologies are incorporated by over 1900 system integrators, security firms, and providing enterprises of hardware related systems globally in their products, catering to millions of customers.[22]

Furthermore, BCIs have become increasingly popular among healthy individuals for significant improvement objectives in the field. During Neuralink's launch event, Elon Musk stated that their venture's objectives are to comprehend and treat brain disorders, protect and improve healthy brains, and create a future in which these aims are aligned. The Royal Society predicts that by 2040, neural interfaces for therapeutic purposes will advance and broaden their scope.[23] At Neuralink's launch event, Elon Musk outlined the extended and breaking ground company's objectives, which would include, inter alia, understanding and treating brain disorders with more efficiency, enhancing and safeguarding healthy brains from potential afflictions, and creating a future in which these goals

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[19] Naila Samar Naz, et al, "Ethical Issues of Brain-Computer Interface." [2018, 18, No. 5] *International Journal of Computer Science and Network Security*, p, 21.

[20] Liv, "Neurolaw", Op. cit., p,330.

[21] Bowman, "The Neurotechnology and Society Interface," Op. cit., p, 9.

[22] Neurotechnologija, "Neurotechnologija Changes Corporate Name to Neurotechnology, https://www.neurotechnology.com/press_release_neurotechnologija_changes_corporate_name_to_neurotechnology.html. [accessed on 4/5/2023].

[23] Liv, Op. cit., p, 330.

are aligned supposedly to serve and upgrade human beings' abilities. According to the Royal Society, neural interfaces which are designed to accomplish numerable therapeutic purposes are expected to advance and expand their scope by 2040 far more effectively. To wrap up, neurotechnologies, in its true sense, have been in existence for approximately five decades, but they have only shown significant progress in the last 20 years.[24]

3. Revolutionizing Medicine and Science: Neurotechnology's Expanding Applications

Neurotechnology applications and objectives are numerous and can be found in a broad spectrum of fields, specifically the domain of healthcare, research, education, entertainment and even for military purposes.[25] In 2004, Lynch would predictably suggest that the utilization of advanced biochips and brain imaging to combine data will likely accelerate the progress of neurotechnology in the near future. The progress made in the neurosciences, combined with the rapid advancements in neurotechnologies, is leading to the expansion of brain research and clinical applications beyond the realm of strictly medical use.[26] In addition, the BCIs technology is advancing rapidly, both in terms of hardware, with the current state-of-the-art involving the use of more than 300 electrodes permanently implanted in the brain, and software, as computers become better at interpreting brain signals and commands. Early studies involving humans have demonstrated that even individuals who are severely paralyzed can control a computer cursor using just one electrode.[27] Researchers worldwide are developing various forms of neurotechnology that offer new therapies for mental illnesses and neurological diseases like Alzheimer's, schizophrenia, stroke, post-traumatic stress disorder, depression, and addiction. With these advances, neurotechnology presents infinite possibilities to transform daily life.[28]

In the healthcare sector, neurotechnology is used to diagnose and treat a variety of neurological disorders, such as epilepsy,[29] as the deep brain stimulation (DBS) is an approved method for treating various crippling cases, such as dystonia, Parkinson's disease, substantial perilous tremor, epileptic sickness or epilepsy, and obsessive-compulsive disorder. In addition, research is being conducted on DBS as a possible medication which is applicable for various conditions such as Tourette's syndrome, Huntington's disease, chronic pain, traumatic brain injury, dementia, addiction, major depression, stroke recovery, cluster headache, and multiple sclerosis.[30] Neurotechnology applications have also been used to develop prosthetics that can be controlled by the brain, allowing individuals with amputations or spinal cord injuries to regain mobility.[31] In reality, medical applications associated with neurotechnology extend to numerable areas, some of which are well-established while others are in different stages of development. These include auditory prosthetics for hearing restoration,

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[24] Roberto Manzocco, *Transhumanism: Engineering the Human Condition History, Philosophy and Current Status*, (Switzerland: First Edition, Springer Nature, 2019), p, 191.

[25] UNESCO, Report of The International Bioethics Committee of UNESCO (IBC) on the Ethical Issues of Neurotechnology available at https://unesdoc.unesco.org/ark:/48223/pf0000378724, pdf, para95. (15 December 2021) [accessed on 11/4/ 2023]; UK Ministry of Defence, *Human Augmentation; the Dawn of a New Paradigm*, https://www.gov.uk/government/publications/human-augmentation-the-dawn-of-a-new-paradigm (13 May 2021), p, 33.

[26] Julian Savulescu, Ruud ter Meulen, Guy Kahane, eds. *Enhancing Human Capacities*. (USA: First Edition, John Wiley & Sons, 2011), p,157.

[27] Anders Sandberg, "Cognition Enhancement: Upgrading the Brain," in Savulescu, Kahane, Op. cit. p,76.

[28] Rafael, "It's Time for Neuro-Rights," Op. cit., p, 155.

[29] James, *Neurotechnology:* Op. cit., p, 230.

[30] UNESCO, Report of The International Bioethics Committee, op. cit. p,19.

[31] McCay, "Horizon Report", Op. cit. p, 11.

visual prosthetics for vision restoration, different forms of neurotechnology for neurological and psychiatric disorders, and hippocampal prosthetics that aim to enhance memory.[32]

The remarkable progress in brain science and technology over the past three decades has made it possible for brain-machine interfaces to help people with paralysis move and feel, enable deaf individuals to hear, and partially restore sight to the blind. While this may seem like something out of science fiction to many, it is now a reality. These powerful neurotechnologies have shown potential in treating various brain disorders and diseases, and are also being used for recreational and mental enhancement purposes.[33] Looking ahead, the astounding advancements which have been accomplished in the domain of neurotechnologies and genetic engineering are highly likely proceeded to set up the stage for the creation of "neuroceuticals" and "geneceuticals," which target specific sensitive and strategic neural circuits in the brain and modify our emotional capacities on a genetic level. Further, these neuromodulators would offer similar influential effects to the currently available pharmaceuticals but with greater efficiency and fewer side effects. However, as the demand for mood enhancement surges in the industrial society and proliferation of technology, operative regulatory laws and regulation which have been designed primarily for conventional therapeutic pharmaceuticals would seemingly prove insufficient.[34]

Literature indicates that the likelihood of successfully developing therapies for central nervous system (CNS) disorders, particularly Alzheimer's infectious malady and similar types of dementia, is lower than for many other types of illnesses. CNS drugs are generally more difficult to create than other medications due to the chronic and complicated nature of nervous system disorders, and the difficulty in accurately measuring the outcomes of clinical trials. Additionally, the brain is a challenging area to study and treat, making it tough to develop precise models and reach therapeutic goals. Notwithstanding, the use of neurotechnological tools may help bridge the diagnostic and therapeutic gap in brain disorders and potentially reduce the significant costs associated with caring for aging populations worldwide. The development of personalized medicine, driven by functional brain maps and individual genetic diagnoses, could also be aided by these tools. In this context, scientists are now utilizing advances in areas such as nanotechnology, synthetic biology, and genomic research to develop technologies that allow for dynamic monitoring and assessment of complex neuronal structures with high spatial and temporal resolution.[35]

On the other hand, while restoring sensory and motor function through neurotechnology is an impressive accomplishment, the most complex and intriguing advancements are those that alter our emotions, memory, and cognitive abilities. For instance, DBS, which is designed to provide treatment for Parkinson's disease, can now be used to treat patients with treatment-resistant depression, the most severe form of depression that has not responded to other treatments. By electrically stimulating the brain areas responsible for processing emotions and regulating behavior, severely depressed patients have shown significant improvements in depressive symptoms.[36] In this sense, a 36-year-old woman who has experienced severe depression since childhood received an implant of a closed-loop neuromodulation system to detect changes in her brain activity that are associated with the onset of sad thoughts or feelings. The device identified these biomarkers and provided a brief dose of electricity for six seconds, which rapidly reduced her symptoms and a year later, the woman

[32] UNESCO. (2019). The Ethics of Neurotechnology. International Bioethics Committee. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000373318, para 25, 26/ p9. [12/4/2023].

[33] UNESCO The Risks and Challenges of Neurotechnologies for Human Rights, https://unesdoc.unesco.org/ark:/48223/pf0000384185. p,10. (2023) [accessed on 25/3/2023].

[34] Julian, Meulen, Kahane, eds. *Enhancing human capacities*, Op. cit., p, 247.

[35] Diana M., "The Neurotechnology and Society Interface" Op. cit., p, 9.

[36] UNESCO The Risks and Challenges of Neurotechnologies, Op. cit., p, 12.

reported that her intense emotions and feelings of darkness had diminished, and the repetitive negative thoughts had stopped.[37]

Furthermore. over the last decades, neuroimaging has emerged as the primary research method for studying the connection between the structure and function of the human brain while it is alive, Particularly, in the field of behavioral and cognitive neuroscience, neuroimaging has become the primary method.[38] Neuroimaging techniques would enable researchers to acquire sufficient date from mind through conducting either direct or indirect examination on the construction and operating functions of the central nervous system, as indicated by electrical activity, oxygen and/or energy consumption, and neurotransmitter release, among other factors,[39] as such data allows cognitive neuroscientists to make inferences about the involvement of specific brain regions in cognitive functions.[40] similarly, one of the most fascinating uses of BCI technology is its application in rehabilitating individuals who suffer from severe motor impairments. This includes patients diagnosed with amyotrophic lateral sclerosis (ALS), a disease that renders them incapable of performing any physical movement as the nerve cells responsible for transmitting signals to the muscles deteriorate and eventually die. BCI-based systems can help these patients perform everyday activities such as operating household appliances or even controlling a wheelchair, thus restoring a degree of independence to their lives.[41]

The potential of neurotechnology to enhance significant human conditions and propel our species forward is immense. However, due to its transformative nature, it presents unprecedented challenges to human rights that were not anticipated by current human rights instruments. As a result, existing regulations might fall short in providing comprehensive and robust protection for human rights in a neurotechnological world. Therefore, a new framework of neuro-rights is needed to address these issues.[42] The following discussions will delve into specific topics related to this matter.

4. The Future of Privacy in a Neurotechnological World: The Vital Need for Neuro-Rights

The issue of privacy is a significant concern in the context of brain-computer interfaces.[43] Traditionally, the bioethics of right to privacy has been revolving around the issue of protecting and developing ethical issue associated with the medical records. However, with the emergence of these astonishingly unprecedented interfaces, there is a new concern regarding the potential for manipulating the unwarranted accessibility to clients' mental processes, which can be easily derived from their neural activities. Situational factors can be correlated with continuously recorded brain activity using current technologies to deduce psychological information; for instance, the attempt to analyze patients' overflowing brain activities during the time of watching the televised news would reveal their actual internal and hidden responses to the quality and quantity of broadcast content associated with different political or otherwise intellectual ideologies and beliefs, and additional personality traits. Our behaviors, such as communications and the way of shopping we make as habits,

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[37] Katherine W. Scangos, et al, "Closed-loop Neuromodulation in an Individual with Treatment-resistant Depression." 27, no. 10 (2021, 27, No. 10), *Nature Medicine*, p, 1696.

[38] Karl J. Friston, "Modalities, Modes, and Models in Functional Neuroimaging," [2009, 326, No. 5951] *Science*, p, 399.

[39] O. Carter Snead, "Neuroimaging and Capital Punishment," [2008, 19], *The New Atlantis*, p,37.

[40] Russell A. Poldrack, "Can Cognitive Processes be Inferred from Neuroimaging Data?" [2006, 10, No. 2] *Trends in Cognitive Sciences*, p, 59; Sjors Ligthart, "Coercive Neuroimaging, Criminal Law, and Privacy: a European Perspective," [2019, 6, No. 1], *Journal of Law and the Biosciences*, p, 291.

[41] Naz, "Ethical Issues of Brain-Computer Interface," Op. cit. p, 21.

[42] Yuste, Op. cit. p,155.

[43] Anisha Agarwal et al, "Protecting Privacy of Users in Brain-computer Interface Applications," [2019, 27, No. 8], *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, p, 1547.

have already become more accessible and apparent to the surrounding agencies, and in an era of developing such instrumental devices that continuously grasp and read out brain content, our minds will likely become more transparent.[44]

The concept of the right to privacy is a fundamental aspect found in several legal systems and constitutional provisions, aimed at limiting both private and governmental actions that pose a threat to individuals' privacy, Recently, in the era of mind-boggling developments in neurotechnology, this issue has been the subject of extensive national and international discussions. From this perspective, an ongoing debate revolves around whether the right to privacy can coexist with the current abilities of artificial intelligence applications, particularly neurotechnology. Given that this emerging technology has the potential to access and analyze almost every aspect of an individual's life by penetrating their mind. Furthermore, there is a significant question regarding whether sacrificing the enjoyment of right to privacy shall be seen inevitable as part of the social contract to enhance defense against perceived neurotechnological risks and challenges.[45]

Samuel Warren and Louis Brandeis were the pioneers of describing a legal right to privacy, which they defined as the right to safeguard one's "inviolate personality" from any form of intrusion or unwarranted exposure. Their argument was essentially for a "right to be let alone." Brandeis' concept of privacy, particularly in relation to state intrusions, was eventually recognized as established Constitutional law. It is grounded in the explicit protection provided by the Bill of Rights against government intrusion into personal effects and the home, as well as the implicit protection of individual autonomy and freedom.[46] Privacy has been a fundamental concern throughout human history, although the modern notion of privacy is a relatively recent development. In the past, privacy interests were implicitly protected through legal and social measures that safeguarded personal property, intimate spaces, and personal possessions. However, with the advent of new technologies in the 20th century, privacy became an independent concept, as scholars recognized the need to protect individuals from new intrusions into their private lives brought about by innovations such as the telephone and airplanes. Over time, the law has attempted to keep pace with these technological changes, albeit slowly, in an effort to safeguard the realm of the private. The digital age, characterized by computing, databases, the internet, and mobile communications, has presented new challenges to privacy rights, necessitating a further evolution of both legal and conceptual frameworks. However, unlike previous technological advancements, the scale and scope of the digital revolution are so vast that privacy law is struggling to respond in a timely manner, leaving individuals vulnerable to invasions of their privacy.[47]

In essence, the right to privacy is indeed recognized as a fundamental human right under Article 12 of the Universal Declaration of Human Rights Act, 1948, which stipulates that: "No one shall be subjected to arbitrary interference with their privacy." This provision reiterates the importance of safeguarding individuals' privacy from undue and unwarranted intrusions, whether by governmental or private actors. The acknowledgment of the right to privacy as a basic human right has been reaffirmed by numerous international treaties and declarations, underscoring its significance as a cornerstone of human dignity and freedom. According to Article 8(1) of the European Convention on Human Rights (ECtHR) every person has the right to have their private and family life, home, and

[44] Martha J. Farah "An Ethics Toolbox for Neurotechnology," 86, no. 1 [2015, 86, No.1], *Neuron*, p, 36.

[45] To delve deeper into the topic of protecting the right to privacy in the age of neurotechnology, a recommended source is the book "Protecting the Mind: Challenges in Law, Neuroprotection, and Neurorights," edited by Pablo López-Silva and Luca Valera. This volume, published by Springer Nature in 2022, offers extensive discussions and analyses of the legal and ethical challenges posed by neurotechnology and its impact on individuals' privacy and rights.

[46] Will Thomas DeVries, "Protecting Privacy in the Digital Age," [2003, 18], *Berkeley Tech. LJ*, p, 286.

[47] Ibid, p, 284-5

correspondence respected. When assessing whether certain information held by authorities falls under protected aspects of private life, the ECtHR considers factors such as the specific context in which the information was obtained and retained, the nature of the records, the way in which they are processed, and the potential outcomes that may arise.[48] Likewise, the adoption of the Arab Charter on Human Rights during the Arab League summit held in May 2004 was regarded as a positive development in the reform movement that impacted the Arab world. The charter became operational in March 2008, and the right to privacy is considered a crucial provision within it.[49] On the national level, as per Article 17/1 of the Iraqi Constitution stipulates that individuals are entitled to their right to personal privacy as long as it does not violate the rights of others or public morals.[50] Thus, it is universally acknowledged that the right to privacy is a fundamental human right that must be respected at all times, regardless of geography or social environment. However, recent developments in the field of neuroscience and neurotechnology have raised concerns about the potential violation of this right. Additionally, with the advancements associated with neurotechnological discoveries, the issue of mental privacy is at stake which is no longer secured sufficiently; the nervous system is responsible for the majority of brain which is almost generated involuntarily and beyond individuals' complete conscious control, which means that a person can unintentionally or unknowingly disclose brain data while being put under surveillance.[51]

The unique ethical concerns raised by neurotechnology stem from its direct interaction with and impact on the brain. Unlike previous technologies, neurotechnology has the potential to access and manipulate sensitive information and learned behaviors stored in the brain. This presents a real possibility of information being accessed in ways that were once thought impossible. For instance, decoding brain images in response to questioning could be used to effectively interrogate prisoners or kidnapped leaders, posing a major national security threat. Additionally, what if an employer's hiring algorithm discriminated against a candidate based on a misinterpretation of their brain data? Because algorithms have been known to develop biases similar to humans, such as racial or gender-based biases. In reality, each of such scenarios and sequenced events will bring to light a distinguishable ethical dilemma grew out of neurotechnology employments, which can be intendedly or accidentally manipulated by its operators.[52]

In this connection, there are individuals who are apprehensive about these matters. Arthur Caplan, a renowned bioethicist and Director of the University of Pennsylvania Center for Ethics, has expressed his concerns by stating that the advancements in brain reading technology could be misused for screening job applicants, diagnosing and treating illnesses, and deciding who is eligible for disability benefits.[53] Some people fear that their brain could be used against them in some way. The utilization of low-cost mechanical means for widespread surveillance is becoming increasingly feasible with the emergence of technologies like voice and facial recognition, enabling machines to assume a greater role in monitoring. There are even reports indicating that machines are capable of rudimentary mind-reading by detecting brain reactions to stimuli like photographs.[54] The term "brainome" has even been coined, akin to "genome." Donald Kennedy, a neurobiologist and the editor-in-chief of science, has remarked that he does not want his genome to be known by his employer or insurance company, let

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[48] Ligthart, 'Coercive Neuroimaging, Op. cit. p, 294.

[49] Hala Ahmed Mohammed Al-Douri, "The Impact of Technological Developments on the Right to Privacy," [2022, 11, No. 42], *Journal of College of Law for Legal and Political Sciences*, p, 608.

[50] Iraqi Constitution of 2005.

[51] Yuste, Genser, Herrmann. "It's Time for Neuro-Rights," Op. cit. p,160.

[52] Ibid, p,159.

[53] J. O'C. Hamilton, "If They Could Read Your Mind", Stanford Magazine (January/February 2004) available at https://stanfordmag.org/contents/if-they-could-read-your-mind [accessed on 15/4/2023].

[54] Martha Bridegam, *The Right to Privacy* (USA: First Edition, Chelsea House Publishers, 2003), p, 53.

alone his brainome, which he considers to be his most intimate identity. With the advent of "brain fingerprinting" and other related technologies, as well as the progress of research, privacy concerns associated with neuroscience are bound to intensify.[55]

At present, even in developed countries such as Canada and the United States,[56] where privacy protection is a significant concern, there are weak legal provisions to safeguard individuals from the potential adverse effects of multiple applications of neurotechnology. This is largely due to the lack of constitutional protection for health-related data.[57] In countries like Iraq, where neurotechnologies have not yet been introduced, this right is even less protected, highlighting the need for greater consideration of this issue in the future. In contrast, the European Union offers more precise protection for individuals' rights in this regard; this encompasses the entitlement to not be subjected to analysis of sensitive information, the right to receive an explanation, and to have personal data erased (right to be forgotten).[58] More importantly, the use of neurotechnology applications by the state, military, and employers is a further concerning dystopian scenario. This is because BCIs have the potential to grant access to our most private thoughts and emotions, which could be exploited by those with power and influence. The governments of the United States, China, and other countries have led a revolution in neurotechnology. They are not only developing medical neurotechnology but also non-medical neurotechnology for military and surveillance purposes.[59] Currently, brain-reading technology is being used in China's government-backed surveillance projects to detect changes in emotional states among production line employees and high-speed train drivers,[60] and there is no guarantee that such policy is not going to predominate the entire world.

On the other hand, clinical experiments and making applications for tissue grafting, BCIs with externally attached or internally implanted chips or devices, DBS, and many forms of noninvasive brain stimulation are already underway. While some ethical concerns raised by these technologies are similar to those encountered in other biomedical fields, there are also novel ethical considerations unique to the way these technologies interact with the brain. As a result, fresh ethical analyses are necessary to address these issues. Neurotechnology has a range of applications beyond medical use, aimed at improving the quality of life or performance of healthy individuals. As these technologies become more commonly used for therapeutic purposes, it is likely that non-therapeutic uses will emerge, as has been the case for other medical treatments such as plastic surgery and psycho-pharmacology. In fact, some people already use non-invasive brain stimulation techniques to enhance their mood, concentration, or gaming skills.[61]

5. Neurotechnology and the Challenge to Personal Autonomy

Neurotechnology also poses new challenges to personal autonomy. DARPA's RAM and SUBNETS programs suggest that the ability to direct and imposing control over cognitive and emotional processes is not just a work of fiction, but a reality which is already underway. The capacity to deliver stimulating techniques to the sensitive parts of brain are equipped with sufficient potential to systematically manipulate overflowing thoughts, emotions, and behaviors, whether it is carried out by hackers or an authoritarian regime. When analyzing the ethics of clinical neurotechnology, whether through the lens of deontology or consequentialism, the outcomes are similar, and if we

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[55] New York City Bar Association. “Are your thoughts your own? Neuroprivacy and the legal implications of brain imaging,” *New York: The Committee on Science and Law* (2005), [16/4/2023]. p,10.

[56] Ibid, p, 10.

[57] Lydia Montalbano, “Brain-Machine Interfaces and Ethics: A Transition from Wearable to Implantable,” [2021, No. 16] p,199.

[58] Ibid, p, 200.

[59] Yuste, Genser, Herrmann. “It’s Time for Neuro-rights,”, Op. cit. p,157.

[60] Liv, “Neurolaw”, Op.cit. p, 345.

[61] Martha J. “An Ethics Toolbox,” Op. cit. p, 36.

focus on the consequences of the technology, it becomes evident that hijacking BCI and DBS systems could have extremely damaging and aggressive consequences.[62]

The principle of personal autonomy is a fundamental concept under constitutional law, which pertains to an individual's capacity to decide on matters related to their own life, without unjustifiable interference from external parties or the government.[63] The primary implication of being recognized as autonomous is the ability or freedom to make choices independently, without any external influence or coercion, and with the expectation that those decisions will be respected and enforced by others. Additionally, it signifies that no one has the right to intrude upon our physical or mental faculties without our explicit consent, except in situations where obtaining consent is not feasible.[64] In this sense, granting autonomy to an individual acknowledges that they hold the sovereignty and ultimate power over their own life, recognizing that every person has only one life and what occurs within it is their personal and private matter of utmost significance.[65]

Accordingly, when examining autonomous behavior within the context of typical individuals, it is characterized by three key elements; 1) a deliberate and purposeful decision-making process; 2) a comprehensive comprehension of the situation at hand, and 3) the absence of any external forces or pressures that dictate their actions. This concept of autonomy has been developed to align with the notion that the everyday choices made by generally capable individuals are considered autonomous.[66] Thus, it is evident that individual autonomy is rooted in the alignment between an individual’s motives and actions, which generates a sense of personal agency, and the ideal scenario is when these actions are consistent with the stable and enduring aspects of the individual's character, inclinations, and ethical principles.[67]

In the context of national law, Article 42 of the Iraqi Constitution is a fundamental provision that recognizes the importance of freedom of autonomy and thought for every individual. This article asserts that every person has the right to hold and express their own beliefs and opinions, without fear of censorship, oppression, or persecution. It is a vital aspect of individual liberty, allowing people to explore their own ideas, perspectives, and experiences, and to engage with others in dialogue and debate.[68] Moreover, the Civil Code in Iraq takes the protection of this right seriously, as it recognizes that any infringement of this right is a violation of a person's dignity and human rights. (Art. 205) In fact, it considers it an offense and has provisions for adequate compensation in case of its breach, as this demonstrates the significance of the right to freedom of thought and the responsibility of the society and the government to safeguard this right; furthermore, it ensures that individuals are free to explore their thoughts and ideas without fear of persecution, and their mental autonomy is protected.

In reality, as the report of the International Bioethics Committee of UNESCO would argue, the right to autonomy, which is critical to human life and liberty, faces significant challenges due to advancements in neurotechnology. The ability to conduct cognitive surveillance, manipulate or alter cognitive functions, decode brain activity, and potentially even write new thoughts, can potentially interfere with cognitive processes and compromise an individual's ability to make free and competent

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[62] Ibid, p, 36.

[63] Take a look at Articles 38 through 44 in the 2005 Iraqi Constitution as an example.

[64] Sheila A.M. McLean, *Autonomy, Consent and the Law*. (First Edition: Routledge, 2009), p, 40.

[65] Peter Alldridge, Christine Harriet Brants, *Personal Autonomy, the Private Sphere and Criminal Law A Comparative Study* (USA: first edition, Bloomsbury Academic, 2001), p, 59.

[66] Tom L. Beauchamp, James F. Childress. *Principles of Biomedical Ethics*, (Brazil: seventh edition, Edicoes Loyola, 1994), p, 104.

[67] Philipp Kellmeyer, et al, “The Effects of Closed-Loop Medical Devices on the Autonomy and Accountability of Persons and Systems,” 25, no. 4 [2016, 25, No. 4], p, 624.

[68] Iraqi Constitution of 2005.

decisions. However, losing one's autonomy means losing the capacity for freedom, but not the entitlement to pursue it. Therefore, safeguarding the effectiveness of the right to freedom requires considering the level of vulnerability that an individual may face and when discussing neurotechnologies, it is important to consider two distinct issues with relation to autonomy. The first pertains to a individuals capability to give their consent to the employment and extension of neurotechnology into their body, whether they are a patient receiving therapeutic treatment or a consumer of a medical or non-medical grade device, and the second issue shall focus on the collection, handling, usage, and sharing of neural data, as detailed in the legal section. Additionally, ethical concerns arise regarding the impact of therapeutic neurotechnologies on a person's autonomy and identity, as they may be restored or disrupted as a result of brain intervention or manipulation of neural activity.[69]

6. Ethical Concerns and Liability in the Advancement of Neurotechnology

In addition to the above-mentioned challenges, as neurotechnology continues to advance at a breakneck pace, ethical concerns loom large in the field of neuroethics. One particularly salient issue is that of liability, which takes center stage in drug and BCI research. The accuracy and processing of signals in BCI systems are critical, and any error during the scanning process can have serious consequences. In fact, the potential for unintended consequences raises pressing questions about responsibility for the wrong actions associated with the technology; for instance, if a BCI system misinterprets a user's intended command, the resulting discrepancy between intention and action could have disastrous effects, such as a BCI-powered robot damaging property or even injuring a person. In the face of such risks, it is imperative that the question of who or what should be held accountable for such harms is addressed head-on.[70]

As G. Marchant and L. N. Tournas would argue with the advent of AI-powered neuro-technologies, the role of devices has shifted from mere tools for physicians to decision-makers in their own right. These devices rely on algorithms that continuously learn, much like the development of a human physician who synthesizes assimilated data over time. However, a crucial difference arises in the realm of liability, because while a human physician is held to a negligence standard of liability that allows for a certain degree of reasonableness, the machine is held to a product liability standard where strict liability applies. This means that the device could be penalized for learning, even if it is performing with greater accuracy than its human counterparts.[71] Henceforth, such a state of affairs raises important ethical concerns that need to be addressed under national law particularly within the complementary regulations of Civil Code and health care law.

The law's crucial role in shaping the future of scientific breakthroughs cannot be overlooked, especially in the context of the law of delict. Despite potential advancements in neuroscience and the possibility of adopting neurotechnology applications, the law's fundamental inquiry into human behavior remains unaltered. This is because the law does not merely describe human conduct; but rather it prescribes our behaviours. In other words, the law sets out a normative framework for what people should do, and it does so with a structured approach that is unique to the legal discipline.[72]

A further issue to consider is that of augmentation, the adoption of neurotechnologies for the purpose of enhancing human conditions, such as those that would enable individuals to expand their ability of endurance during the time of pain or sensory and mental related capacities, will likely result in societal pressure to adopt such technologies. This pressure will also cause the modification of societal norms transformation and brings about serious concerns in relation to equitable access and new forms

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[69] UNESCO. (2019). The Ethics of Neurotechnology, Op. cit., p, 27-28.

[70] Naz, et al, “Ethical Issues of Brain-Computer Interface,” Op. cit. p, 23.

[71] Gary Marchant, Lucille Nalbach Tournas, “Matter Over Mind: Liability Considerations Surrounding Artificial Intelligence in Neuroscience,” in Fabrice Jotterand, Marcello Ienca eds*, Artificial Intelligence in Brain and Mental Health: Philosophical, Ethical & Policy Issues*, (Switzerland: First Edition, Springer Nature, 2021), p, 238.

[72] Jan M. Smits “Does the Law of Delict have a Future? On Neuroscience and Liability” [2015, 17], p,457.

of discriminatory prejudices against those who would not be able to afford or do not want to use these technologies. Furthermore, an 'augmentation arms race' could emerge, with DARPA and the US Intelligence Advanced Research Projects Activity discussing plans to provide soldiers and analysts with enhanced mental abilities for combat and data analysis. As it is problematic bring into prediction domain the idea of which technologies will impact human life negatively, setting up regulatory measures and guidelines at both national and international scales is of paramount significance to set constraining limits on the augmenting neurotechnologies that can be enforced and to explain the contexts in which they can be utilized, similar to how gene editing in humans is regulated. Given the potential for discrimination, societal pressure, and an arms race, guidelines are needed to ensure equitable access and responsible implementation of enhancing neurotechnologies.[73]

There is a significant possibility that we may soon have the ability to manipulate human minds and behavior by 'hacking' the brain, coupled with our ability to decode and encode brain signals. This potential has been crudely demonstrated in previous experiments involving rats when researchers implanted a small device, roughly the size of a peppercorn, into the brain of a mouse. Using a wireless power system, the device emitted a blue light that activated genetically modified brain cells located in the premotor cortex. These cells are responsible for transmitting signals to the muscles.[74] Although current neurotechnology does not allow for it, proactive policies must be put in place to prevent potential misuse. Further, as our understanding of the brain improves and we discover ways to suppress anxiety or depression, this knowledge could be misused to manipulate people's mental states, inducing emotions such as anxiety or depression. This could lead to more direct and effective forms of manipulation, endangering cognitive autonomy and individual integrity. Therefore, it is critical to establish safeguards to ensure responsible use of these technologies.[75]

7. Closing Thoughts and Recommendations:

7.1. Final Reflections:

The findings of the study expounded that neurotechnology is a rapidly evolving field that enables direct communication between the human brain and machines, with the potential to augment human capabilities. However, it became apparent that this technology poses ethical and social dilemmas that require careful consideration, particularly in the areas of BCIs and interventions that alter brain activity. Neurotechnological instruments can be classified as assessment or interventional, and policymakers can customize regulations and policies to assess their advantages and drawbacks more efficiently. Regarding the historical roots of this technology, litterateur indicates that the scientific community in the second half of the 1800s experienced a significant growth due to the introduction of new instruments that allowed for more intricate and sophisticated observation and experimentation. One pioneering figure in the study of the brain was Paul Broca, whose work laid the foundation for the field of neurotechnology and neuroscience. Later on, in the mid-20th century, neurotechnology advanced rapidly with the invention of the EEG, a widely-used tool for diagnosing brain abnormalities globally.

The development of the threshold logic model by Warren McCulloch and Walter Pitts in the 1940s paved the way for the brain to be studied using two distinct approaches. On the other hand, neurotechnology is a rapidly developing field with numerous applications in healthcare, research, education, entertainment, and the military. The development of advanced biochips and brain imaging techniques has led to significant progress in the field, and one of the most promising areas of development is BCIs, which enable even severely paralyzed individuals to control a computer cursor.

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[73] Rafael Yuste, et al. "Four ethical priorities for neurotechnologies and AI," *Nature* 551, no. 7679 (2017), p,162.

[74] IEEE SPECTRUM, Neuroscientists Wirelessly Control the Brain of A Scampering Lab Mouse, https://spectrum.ieee.org/neuroscientists-wirelessly-control-the-brain-of-a-scampering-lab-mouse (28, November, 2016), [accessed on 12/4/2023].

[75] Federico Mantellassi, In focus: The Challenges of Neurotechnology, (11. April, 2011) https://www.gcsp.ch/global-insights/focus-challenges-neurotechnology

In healthcare, neurotechnology is used to diagnose and treat various disorders that may afflict brain and associate with neurological systems such as dystonia, epilepsy, Parkinson's disease, obsessive-compulsive disorder, and serious forms of tremor.

On the flip side, these developments are not free of legal and ethical risks and challenges; in the context of BCIs, privacy is a significant concern, for instance unauthorized access to individuals and specifically patients' mental processes are a new concern that must be addressed under national and international law instruments, because the available technologies can effortlessly infer psychological information and comprehend individuals state via continuously recorded brain activities correlated with situational factors, leading to concerns about privacy. Further, neurotechnology poses significant challenges to personal autonomy due to the potential manipulation of cognitive and emotional processes through brain stimulation. Also, ethical concerns arise regarding the impact of therapeutic neurotechnologies on a person's autonomy and identity; two key issues related to autonomy in the context of neurotechnology are the ability to give consent to the use of neurotechnology on one's body and the handling, usage, and sharing of neural data. Likewise, the field of neuroethics is facing major ethical concerns due to the rapid advancements in neurotechnology in relation to liability which is a significant issue in drug and BCIs research, where errors during the scanning process can result in unintended harm caused by the technology. Yet, the question of accountability for such harm remains a challenge for the field. Moreover, the use of enhancing neurotechnologies for augmentation purposes raises concerns about equitable access, new forms of discrimination, and the need for guidelines to ensure responsible implementation and prevent potential misuse, such as the manipulation of human minds and behavior.

7.2. Direction for Future Endeavors

Bioethicists and researchers have proposed a new framework called "neuro-rights" to address the existing gaps under human rights regimes and protect individuals from potential issues caused by neurotechnology. The proposed neuro-rights shall comprise a set of human rights that protect the brain, such as the right to identity, agency, mental privacy, fair access to mental augmentation, and protection from algorithmic bias. These neuro-rights expand on existing human rights that safeguard human dignity, liberty, security, non-discrimination, equal protection, privacy and liability for wrong actions.[76]

As far as this research is concerned, the author contends that these interventions can have profound effects on the brain and its functions, whether intended or not, and raise complex ethical questions, especially in cases where changes in personality may be desired in the treatment of certain affective disorders, therefore it is crucial to provide significant recommendations related to the rights of individuals. In the rapidly advancing field of neurotechnology, the development and implementation of effective regulations and policies are crucial. By doing so, policymakers can evaluate the benefits and drawbacks of specific products such as spinal cord stimulators and brain-machine interfaces more efficiently, and not group them together with unrelated products like mobile phone apps. These regulations and policies are also necessary to ensure that human rights are protected while using neurotechnologies.

In relation to the right to privacy the law needs to evolve its legal and conceptual frameworks to keep pace with technological changes in the digital age characterized by computing, databases, the internet, and mobile communications. The emergence of neurotechnology and brain-computer interfaces raises new concerns regarding the potential for unauthorized access to patients' mental processes inferred from their neural activity. Accordingly, to safeguard individuals' mental privacy, there is a vital need for "neuro-rights" that focus on protecting their mental privacy; governments, policymakers, and stakeholders must work together to ensure that any advancements in neurotechnology are ethical and socially responsible and do not violate individuals' privacy and rights.

The integration of neurotechnology into medical and non-medical fields has sparked widespread interest, but it also raises ethical concerns in relation to the informed consent. In order to minimize

[76] Yuste, Op. cit. p,160-61.

prejudices, it is necessary to bear in mind that before any neurotechnology is used on an individual, they should be given the right to understand the risks and benefits, and they must have the opportunity to provide their consent freely. Additionally, the potential impact on an individual's autonomy and identity should be considered, as neurotechnology can both restore and disrupt brain function. To prevent any abuse or misuse of neurotechnology, it is essential to develop ethical guidelines that outline its proper use and handle neural data collected from individuals with privacy and security concerns. Finally, recognizing personal autonomy and freedom of thought as fundamental human rights and developing legal provisions that safeguard them, including appropriate compensation in case of infringement, should be a priority to prevent any infringement of individual rights.

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