Neurorights: The Debate About New Legal Safeguards to Protect the Mind

Timo Istace, LL.M.*

ABSTRACT: Unprecedented efforts are made to research and develop technologies that are directly connected to the brain and allow us to access, monitor, investigate, assess, manipulate or stimulate neural processes. This exciting development holds many valuable prospects in the medical context and in other fields of daily life such as entertainment, security or criminal justice. However, it also raises major concerns among ethicists and human rights advocates, who argue that fundamental interests are put at risk as these neurotechnologies result in a growing accessibility and influenceability of the mind. In this article, I will describe how neurotechnologies may affect fundamental interests and how this concern led to the emergence of the concept of neurorights within human rights doctrine and policy. I will first outline the current state of the art and the prospects of neurotechnology, and discuss how this technology impacts the mind. Second, I will examine how this in turn may impact our mental privacy, autonomy, authenticity, personal identity, the self, and non-discrimination. Finally, I will show how these concerns prompted initiatives to establish neurorights as new human rights offering appropriate legal safeguards that protect the human mind against unwanted interference by neurotechnology.

* Timo Istace is a PhD researcher in the field of Health Law and Human Rights Law at the Department of Law, Research Group Personal Rights and Property Rights, University of Antwerp, Belgium. LL.M., University of Antwerp, Belgium, 2020.

Introduction

In 2014, a paraplegic man kicked-off the FIFA World Cup using a robotic exoskeleton directly connected to his brain.[1] In 2019, a multi-person brain-to-brain interface enabled three persons to collaborate in playing a game resembling "Tetris" just by using their mind.[2] Recently, in 2021, a neurodevice allowed a man to write on a computer just by thinking about writing a letter by hand.[3] While we should be cautious not to lapse into a ***neurohype*** narrative—where the prospects of neuroscience are sensationalised in the public and scientific debate—it seems that accessing and influencing the human mind by use of technological devices is making a transition from science fiction to reality. This paradigm shift is facilitated by the rapid development of neurotechnologies, defined as "devices and procedures to access, monitor, investigate, assess, manipulate and/or stimulate the structure and function of the neural systems of natural persons" (OECD, 2019, p. 6).[4] Since the 1990s—The Decade of the Brain—neuroscientists increasingly gain insights in how to record and decode brain activity patterns in order to make interferences on a person's mental states, and in how to influence these mental states by modulating neural processes. This exciting development holds many valuable prospects in the medical context and in other fields of daily life, such as entertainment, security or criminal justice. Therefore, governments as well as private actors (e.g., Neuralink, Facebook, and Kernel) are heavily investing in the research and development of neurotechnologies. However, since these technologies may profoundly impact the human condition and society, they also raise concern among ethicists. Due to the growing attention by ethicists—giving rise to the field of ***neuroethics***—and, in their wake, by legal experts—resulting in the discipline of ***neurolaw***—the ethical threats posed by neurotechnology start to find their way to the agenda of policymakers. On a fundamental level, the question namely arises whether current human rights offer appropriate legal safeguards that protect the human mind against unwanted interference by neurotechnology.

In this article, I will examine the ethical issues that arise in the wake of the threats posed to the mind by neurotechnological development. To this end, I will first highlight the state of the art in neurotechnology. This is essential to avoid unsubstantiated downplaying or overestimating the possibilities and risks of neurotechnologies. This will be followed by an analysis of the ethical considerations that form the basis of human rights concerns and for regulatory and policy actions in the field. This ethical analysis is crucial to establish whether legal initiatives are necessary to protect the human mind. Lastly, I will point out recent policy initiatives that focus on the implementation of neurorights as a new kind of neuro-oriented human rights.

Neurotechnologies and the Mind

In the popular media, spectacular claims are regularly made about the current or future impact of neurotechnologies on the human mind. The "Flow C" from Kernel for instance, a device that records brain activity, is frequently referred to as "mind-reading helmet."[5] But is it really possible for neurotechnologies to read the mind or to influence it? A preliminary issue in this regard is how to define 'the mind'. As indicated by theories in the philosophy of mind, the mind refers to mental states, such as emotions, thoughts, imagination, intentions, perception, and decision-making.[6] For the purpose of this article, it is not required to commit to a specific theory within the mind-brain debate. Even authors who do not hold a functionalist theory or an identity theory of the mind-body relation acknowledge that neuroimaging provides basic insights into the link between brain activity and mental states.[7] Within this analysis, a pragmatic stance will be taken in the sense that it suffices to recognise that mental states are mediated by neurons and thus a correlation exists between these mental states and the physical brain, bearing in mind that the exact relation between the mind and the brain remains for the large part a mystery. As a result of this important nuance, getting insight in the neural activity that takes place in the brain does not as such imply an understanding of mental lives.[6,8]

Neuroimaging technologies

To answer the central question as to how today's neurotechnologies interact with the mind, we have to differentiate between neuroimaging and neuromodulation technologies. Neuroimaging technologies aim at mapping brain structures and functioning. Initially, neuroimaging techniques were developed for the purpose of diagnosing neurological abnormalities within the medical field. However, as neuroscience evolved, functional neuroimaging emerged as an important tool for researching people's mental sphere. Functional neuroimaging techniques, such as fMRI, EEG, and fNRIS enable the recording and analysis of neural activity data. By applying neural decoding methods, this raw neuro data can be processed and interpreted into information on a person's mental states. Research suggests that neuroscientists are (or will be) capable, by using neuroimaging techniques and advanced decoding techniques, of detecting and decoding mental states including intentions,[9,10] visual perceptions,[11-13] conceptual knowledge,[14,15] memory,[16] emotions and moods,[17] dreams,[18] beliefs,[19] consciousness,[20,21] and pain.[22] Techniques for predicting mental traits, such as intelligence or attention abilities, are also rapidly evolving.[23] Although these more permanent traits do not provide information on mental states, they dispose a person towards entertaining a certain mental state.[24]

One of the most important fields in today's neuroscience and -technology is that of Brain Computer Interfaces (BCI). BCI technology detects brain-activity signals—via neuroimaging techniques—translates them into technical control commands, and transfers these to an external device. By doing so, BCI devices connect the brain to external devices so that these can be controlled just by using the mind, bypassing neuromuscular pathways.[25] Currently, BCI has a great potential in the medical context as an indispensable tool in healthcare, from prevention over diagnosis to treatment and rehabilitation.[26] BCI technology shows potential to be used, for instance, to diagnose sleeping disorders[27] and dyslexia.[28] As a rehabilitation tool, it may be used for communication through the hands-free control of a cursor, mouse or keyboard for patients with disabilities, such as locked-in syndrome or ALS[29,30] or for repairing impaired motor-function by integrating BCI into prosthetic limbs[26,31] or wheelchairs. BCI devices which use neurofeedback can be deployed in behavioural training and hold the promise of ameliorating symptom control in patients suffering from a neuropsychiatric disorder.[32] BCI-devices are also expected to be increasingly used outside of the clinical context, for instance as a replacement for a keyboard, touch screen or mouse as a means to interact with devices such as computers.[33]

But how exactly do these neuroimaging techniques interfere with the mind? Neuroimaging applications that enable decoding mental states inevitably lead to the idea of ***mindreading***. Mindreading—also referred to as brain-reading or (less common) neurotechnological thought apprehension—can be understood as the observation of brain structure and/or activity aimed at obtaining insights about mental states.[34] This concept is broader than the mere reading of thoughts as it also entails reading other mental states such as emotions, memories or intentions. The question whether neurotechnologies enable mindreading is much debated. Current discourse on the possibilities of neurotechnology ranges from the perspective that it is merely a matter of time before neurotechnologies are able to accurately read some mental states in real-time,[35] to the more sceptic view that, due to major technical limitations as well as conceptual objections, it is uncertain that neurodevices will ever have real mindreading capacities.[6,36-38]

Currently, neuroscientists are already able to extract basal and piecemeal mental information by decoding brain activity patterns. This collection of mental information can be a goal in itself (e.g., detection of memory or beliefs) or it can be done—as in BCI technologies—with the aim of generating input for external devices. For instance, already today, BCI prosthetics read patients motor intentions from their brain. This can be considered a modest form of mindreading, which is done by expert neuroscientists in specialised and well-equipped laboratory settings. Considering the low external validity of the mindreading research trials,[39] the idea of real-time mindreading outside an experimental setting, however, does not seem feasible anytime soon. Major technical limitations exist concerning the quality of imaging techniques, the requirement of cooperation by the person subjected to mindreading, the portability of imaging equipment, and the difficulty to generalise decoding algorithms in order to apply them more universally. Moreover, even when technological and methodological limitations would be overcome by ground-breaking science, mindreading devices still must be adapted to the specificities of the human brain. Because of the limited insights into the brain and its connection to the mental sphere, this is a formidable hurdle. We can nonetheless conclude that, although getting access to persons' mental content without their cooperation is not feasible today, neurotechnology is already increasingly capable of recording and storing brain data, which may be processed into—albeit piecemeal and limited—information on mental states. Taking into account the direction of neurotechnological developments, it is plausible that future neurodevices will be able to generate real-time information on mental states which is sufficiently accurate and valuable to be used in different medical (e.g., psychiatry or informed consent) and non-medical (e.g., criminal justice) contexts. This plausibility necessitates ethical reflection on future, more advanced mindreading capabilities of neurotechnology.

Neuromodulation technologies

Apart from neuroimaging applications, neuromodulation technologies take an important place in today's neurotechnological developments. Neuromodulation devices "alter, bypass or replace existing neural structures or physiologic processes so as to direct the function of a neural system toward a desired end" (Klein, 2020, p. 329),[40] typically by stimulating the brain by means of electric currents or magnetic fields. Several neuromodulating technologies have been developed, in invasive and non-invasive forms, including Deep Brain Stimulation (DBS) and Transcranial Brain Stimulation (TBS). DBS is an invasive, neurosurgical form of brain stimulation which involves the implantation of electrode arrays into a deep region of the brain where they deliver electrical pulses to specific neuroanatomical targets. It is an established treatment for several neurological and psychiatric disorders, such as Parkinson's Disease, dystonia, epilepsy, and obsessive-compulsive disorder.[41,42] It is also studied as a potential treatment for chronic pain,[40] disorders of consciousness,[43] and many psychiatric and cognitive disorders, including treatment-resistant depression, anorexia nervosa, obesity, posttraumatic stress disorder, Tourette Syndrome, Alzheimer's disease, dementia, anxiety, and addiction.[44,45] DBS is only beginning to realise its full potential and is one of the fastest-growing applications in neurosurgery.[40,46] Nonetheless, DBS is still considered a 'last resort option', only to be used when established pharmaceutical or psycho-therapeutical treatments are unsuccessful.[47] Therefore, it is unlikely that DBS will be used outside the clinical context in the foreseeable future. This is not the case when it comes to non-invasive neurostimulation techniques. TBS techniques involve the placement of a coil—for Transcranial Magnetic Stimulation (TMS)—or electrodes—for transcranial Direct Current Stimulation (tDCS) or transcranial Alternating Current Stimulation (tACS)—on the scalp regions overlying the areas of the brain which are to be stimulated by respectively magnetic fields or electrical currents. Studies show significant potential for the use of TBS in enhancing cognitive processes, such as improving memory.[48] Furthermore, research suggests that TBS is a useful therapeutic option to treat disorders such as Parkinson's Disease, dystonia, multiple sclerosis, epilepsy, chronic pain, depression, anxiety disorders, eating disorders, obsessive-compulsive disorder, schizophrenia, and addiction. However, current data does not yet allow us to establish that TBS is an effective routine treatment in today's medical practice. Although research shows promising results for the treatment of depression and pain, additional research is required to establish sufficient medical efficacy for TBS applications.[49,50]

Two significant developments within neuromodulation technologies deserve explicit attention because of their ethical significance. The first is the development of 'closed-loop' neurotechnologies. These devices detect brain activity patterns that mark a specific upcoming neural event, in order to initiate an automatic therapeutic response. This automatised therapeutic response can, for instance, take the form of the automatic administration of drugs.[51] It can, however, also consist in brain stimulation. Although still in an early stage, fruitful research has been done to create closed-loop DBS devices where a sensor records brain activity and initiates brain stimulation to match patients' clinical needs without any active intervention by the patients themselves or their physician.[52] Closing the loop in brain stimulation devices is widely considered as the future of neurostimulation since it remedies several shortcomings of open-loop stimulation such as delayed adaptability of stimulation parameters.[53]

The second important evolution takes place in the field of optogenetics. Optogenetics is "a method that uses light to control cells in living tissue, typically neurons, that have been modified to express light-sensitive ion channels and pumps" (Towne & Thompson, 2016, p. 1).[54] Optogenetics involves the genetic modification of brain cells to make them sensitive to light and thus eligible for modulation by a light source. Since it facilitates a targeted neural control more precisely than any other neuromodulating technology, it is suggested that optogenetics could take a central place in neuromodulation research and practices.[55] Preliminary research already suggests that it could be therapeutically beneficial as a treatment for epilepsy, Parkinson's Disease, Alzheimer's Disease, chronical pain,[56,57] and neuropsychiatric disorders, such as addiction, depression or anxiety. Nonetheless, optogenetics is currently only approved for a first-in-human trial.[58]

These developments in neuromodulation target writing to the mind, i.e., the influencing or even targeted steering of the mind. Research shows that neurostimulation techniques such as DBS unequivocally impact mental states of patients. Clinical studies have, for instance, exposed significant (unsolicited) psychological effects in patients participating in brain stimulation trials for Parkinson's Disease.[59-62] These studies emphasise adverse side-effects consisting of changes in patients' emotions, cognition, behaviour, and personality traits. More specifically, patients exhibit loss of word fluency and memory, impulsive gambling behaviour, feelings of self-estrangement, hypersexuality, impulsiveness or symptoms of depression, anxiety, apathy, and mania. It is important to stress that these findings are often difficult to interpret because of their small sample size and the combination of medication and DBS.[63] Whereas in these cases the psychological changes are unsolicited side-effects, altering cognition and mood can also be the explicit aim of neuromodulation, for instance when treating patients with neuropsychiatric disorders with DBS. It is thus possible to influence the mind by modulating brain processes, although it should be acknowledged that the underlying mechanisms of brain stimulation are not entirely understood. Even though we know that cognitive abilities can be modulated, the effects of brain stimulation in individuals are still very unpredictable. Targeted writing to or steering of the mind is not possible today but some neuroscientists suggest that it will be in the foreseeable future. They make this claim in a milestone study in which they succeeded in the targeted steering of the behaviour of mice by using optogenetics combined with behavioural training.[64] The scientists involved leave no doubt that it is only a matter of time before this 'mind-steering' will also become feasible in human trials as they state that "what can be done with mice today could be done with humans tomorrow" (Yuste et al., 2021, p. 157).[35]

Fundamental Interests

It is clear that neurotechnological advancements offer tremendous perspectives for patients suffering from neurological and neuropsychiatric diseases. Similarly, taking into account the commercial development of neurodevices for neuroimaging and neurostimulation and their increasing availability to consumers for extra-clinical purposes, such as entertainment (e.g., gaming), wellness, and enhancement (e.g., augmentation of attention abilities), neurotechnology will progressively be used to assist people in daily activities and enhance their quality of life.[65,66] However, as promising as neurotechnology may be, it is also a technology that interferes with the "last refuge of personal freedom and self-determination" (Ienca & Andorno, 2017, p. 1)[67] and gives rise to a variety of severe ethical concerns. It is therefore of critical importance that neurotechnological developments proceed within an ethical and legal framework which takes these concerns into account. Such a framework needs proactive and thorough reflection in order to see if any regulatory action is required.

The ethical concerns referred to here are those related to the impact of neurotechnologies on the human mind. Neurotechnologies, especially when surgically implanted, may evidently also pose considerable risks for a person's bodily integrity.[68] However, the existing bioethical framework—with its key principles beneficence, nonmaleficence, autonomy, and justice[69]—provides adequate guidance to weigh the expected benefits of neurosurgery against these physical risks. This is not the case when it comes to new risks in the form of potential harm to the mind. In this regard, neuroethical concerns emerge with regard to privacy, personal identity, autonomy, authenticity, and discrimination.

1. Mental privacy

Important privacy issues come with the collection, storage, and sharing of neuro-imaging output. First, the notions of neural data and mental data must be differentiated.[70] Neural data is information on the physiological structure and functioning of the brain. When such data is gathered and processed into very personal information, for instance to be used as biomarkers for neurological diseases[71,72] or in an extra-clinical context as a means for person authentication,[73] people have clear privacy interest in this sensitive data as it may reveal their health and mental life. This, however, does not concern mental privacy. Mental privacy is the privacy that we enjoy in relation to our mental contents.[8] It involves privacy interests regarding mental information, i.e., raw brain data which is processed into information on a person's mental states by using innovative technologies and decoding methods. Bublitz argues that this differentiation is relevant since the collection of mental information is ethically and legally more problematic than that of neural information, as it may infringe upon the freedom of thought.[70] Furthermore, the relation between neurodata and mental information is a dynamic one since neurodata may along the line be processed into mental information. Consequently, neurodata needs to be taken into account (to some extent) when reflecting on the privacy of people's mental realm, especially as it is unpredictable what the collected neurodata might, as a result of advances in neurotechnology, be able to tell us in the future about someone's mental states.

Ethicists point out that mental privacy may be affected by progress in neuroimaging "to the extent that neurotechnologies embody somehow a claim that the mind may be open to view" (Rainey et al., 2020, p. 2299).[6] Considering the current state of neurotechnology, I agree that such a claim can rightfully be made since neuroimaging techniques are able to generate rudimental mental information. Although the decoding of mental content without the consent of the person concerned is not possible today and important technical and methodological hurdles remain, further developments could result in the infringement of privacy interests.[39] Alarmistic warnings may thus be undesirable, but, as Farah puts it, "functional neuro-imaging is […] already capable of delivering a modest amount of information about personality, intelligence and other socially relevant psychological traits" (Farah et al., 2010, p. 126).[74] Researchers already succeed in revealing content of people's mental states by collecting and processing brain-activity patterns, for instance by reconstructing visual perceptions of a person, solely on the base of brain-activity patterns.[12] Thus, notwithstanding the very rudimentary ***mindreading*** capabilities of neuroimaging technologies, mental privacy may be put at risk by neurotechnological advancement. We might lose control over our own mental information such as unspoken thoughts, even before they reach consciousness or generate behavioural actions. Since the development of these neural imaging and decoding techniques will unquestionably move forward, it is safe to say that mental information constitutes a new source of very sensitive and personal information which will increasingly be tapped into, in medical and non-medical context. This inevitably comes with privacy risks such as, for instance, the privacy violations that can result from brain hacking. Brain hacking entails the malicious data hacking into brain devices such as BCI[75] and may become a considerable threat to mental privacy as it is already possible in laboratory settings.

Moreover, the concept of mental privacy is intertwined with the concepts of freedom of thought, cognitive liberty, autonomy, and authenticity. Insofar as persons' mental privacy is violated and they have reasons to doubt the private character of their mental sphere, they may not feel free to think their own thoughts.[76] When people would no longer feel free "to reflect upon values, decisions, or propositions without threat of consequences" (Rainey et al., 2020, p. 2302)[6], this may lead to self-censorship and an impaired feeling of autonomy. Where mental privacy is at risk, freedom of thought, personal autonomy, and authenticity face a similar threat.

2. *PIAAAS: Personal Identity, Agency, Autonomy, Authenticity, and Self*

Although brain stimulation may contribute tremendously to alleviating symptoms of neurological diseases, technologies such as DBS and TMS give rise to concerns about personal identity, agency, autonomy, authenticity, and the self,[59] labelled PIAAAS in short by Gilbert and colleagues.[77] The emergence of these concerns is not surprising since "the brain has a crucial role in the functioning of the mind, the body, and the development of self-conceptions and autonomous agency" (Nuffield Council of Bioethics, 2013, p. 15).[62] The notion of PIAAAS is valuable since in the neuroethical literature, the effects of brain stimulation on people's mental states are studied from a variety of intertwined angles. Some authors consider the alteration of mental states by brain stimulation a possible threat to personal identity, whereas others approach similar issues from the angle of authenticity, autonomy, agency or the self. Whatever the angle, these interesting philosophical discussions all revolve around the fact that brain modulation influences persons' mental processes and behaviour, so that the persons themselves, as well as their environment, may end up with a different perception of who they are and what causes their actions. Some argue it may even come down to a "risk of becoming another person following [DBS] surgery" (Witt et al., 2013, p. 499).[78]

Research demonstrates that unsolicited and unpredicted alterations in people's personality, mental traits, and demeanour may occur following brain stimulation.[79] Studies report that patients become more irritable, impatient, and inclined to express their opinion,[61] show aggressive behaviour and impaired impulse control,[80] and even signs of cognitive decline.[81] Other small sample studies show that interference with cognitive processes may result in patients reporting feelings of self-estrangement and failure to recognise themselves as authors of their actions, whereas other patients feel that their brain implant actually empowers them for it re-enables them to undertake actions and pursue goals they were no longer capable of due to neurological or neuropsychiatric pathologies.[82] Similar findings of unwanted side-effects (such as hypomania) have been reported in studies of neurostimulation in patients suffering from major depression.[83] With the further development of new brain stimulation techniques these concerns relating to personal identity, autonomy, and the self will only increase. A prime example is the development of optogenetics techniques that target memory modification.[58]

Similar threats are also posed by BCI applications. For instance, BCI applications may be exposed to malicious cybercrime. Brain hacking, where third parties take control over the BCI device by hacking into it, is not only a major privacy threat but obviously also constitutes a severe threat to autonomy. The physical output of BCI devices can be altered by third parties so that the physical state which a person who, for instance, is using a BCI-driven prosthetic wants to realise, is altered without consent. This reduces the autonomy of that person in the most literal sense since they cannot act in the way they want to but instead will act as the third party decides. Furthermore, significant worries concerning individual autonomy arise with the development of closed-loop BCI's. When, for instance, closed-loop DBS is used to relieve symptoms of a psychiatric disease such as major depression, the BCI technology detects emotional states and anticipates them by initiating brain stimulation. This results in a mechanism which "autonomously determines what the patient may or may not feel" (Klein et al., 2016, p. 2).[84] If the brain device is keeping them in a constant state of well-being, will patients still be able to experience a normal range of feelings? The autonomous and conscious control by patients over the device is thus strongly reduced, which may undermine their autonomous agency. Here, it is relevant whether the person who is subject to closed-loop brain stimulation is in or out of the decisional loop.[85] As it is apparent that BCI's could generate negative effects on people's (feeling of) autonomy, this is an ethical aspect that needs to be taken into account in the further development and implementation of this evolving technology.[86]

3. Neurodiscrimination

The risk of discrimination manifests itself in different ways. First of all, there is a risk that neurotechnologies may themselves be inherently affected by discriminatory mechanisms as Artificial Intelligence is increasingly incorporated in neurotechnological devices, especially for the prediction or analysis of recorded neural data.[87,88] In this light, the risk that an algorithmic bias will be integrated into neurodevices is significant.[89]

Furthermore, tapping into a new source of personal information holds the risk that this information will be used in a discriminatory way. This risk is especially significant for mental information, considering the potentially valuable and personal nature of this type of information in many different contexts. For instance, it is conceivable that in the context of employment, people may be hired because of specific mental traits or certain beliefs which can be observed by neuroimaging. A clear example is provided by Lavazza, who points out that, when a racial bias can be detected by the study of brain patterns, it may be desirable to only hire a police officer whose brain activity does not show any racial bias.[90] This could be highly problematic considering that there is a significant risk of misidentification and that misinterpretation of brain data can lead to the false attribution of mental traits and states. Moreover, when taking decisions on the basis of detected mental states (e.g., thoughts or emotions) or mental traits (e.g., impulsiveness), one disregards a person's ability to internally deliberate and mediate these mental states and traits before translating them into actions. Nonetheless, it must be admitted that differentiating between people on the basis of their thoughts, beliefs or intellectual capacities as uncovered by neuroimaging is not likely to occur in the near future since neurotechnologies do not yet enable the observation of thoughts, beliefs, and other mental contents of non-consenting subjects by non-scientists outside a laboratory setting.

Lastly, similar concerns of discrimination also exist with regard to the enhancement of people's cognition.[91] As Yuste and Goering state, "the pressure to adopt enhancing neurotechnologies, such as those that allow people to radically expand their endurance or sensory or mental capacities, is likely to change societal norms, raise issues of equitable access and generate new forms of discrimination" (Yuste & Goering 2017, p. 162).[92] With the increasing development and availability of neuro-enhancing technology that may in the near future enable cognitive performances superior to current standards, it is crucial to make sure that augmentation status cannot become a ground for discrimination and that fair access to mental augmentation is ensured in order to avoid a new source of social inequality.

Neurorights & Policy

For some decades now, neuroethicists examine the ethical, legal, and societal impact of new neurotechnologies and neuroscientific findings. However, it is only since the millennium change that neuroethicists and neurolaw experts have begun "to look at ethical-legal challenges in neuroscience and neurotechnology in terms of high-level normative principles, such as rights, entitlements, and associated duties" (Ienca, 2021, p. 2).[93] This development gave rise to the notion of "neurorights". Neurorights can be defined as "the ethical, legal, social or natural principles of freedom or entitlement relating to a person's cerebral and mental domain" (idem).[93] The concept of neurorights has become an increasingly important topic within neuroethics and neurolaw since Ienca and Andorno first introduced it in 2017. In the further analysis, neurorights will be understood in their legal dimension.

How did the notion of neurorights first appear in legal doctrine? As human rights emerge as a response where fundamental interests are at risk, the question arises whether human rights law provides us with legal safeguards to adequately respond to the threats posed by the increasing accessibility and influenceability of our minds as a result of neurotechnological developments. Several human rights and fundamental freedoms, such as the freedom of thought, the right to respect for private life (including the right to privacy and the right to personal autonomy), the right to mental integrity, and the right not to be discriminated against, can act as potential safeguards. These rights and freedoms are enshrined in international human rights instruments, such as the Universal Declaration of Human Rights, the International Covenant on Civil and Political rights, the European Convention on Human Rights, and the Charter of Fundamental Rights of the European Union. However, none of these instruments explicitly refers to neurotechnology, nor is neurotechnology addressed in the case law issued by international human rights courts or committees. Perhaps more surprisingly, case law on a possible special status of the mind within the human rights framework is also lacking. Regulations and legal doctrine set the boundaries of what constitutes acceptable interference with one's own body and the bodies of others. By contrast, there is a legal lacuna when it comes to the protection of one's mental integrity by human rights law. Even the right to mental integrity—enshrined in Article 3 of the Charter of Fundamental Rights of the EU and recognised in the case law of the European Court of Human Rights in the context of Articles 3 and 8 of the European Convention on Human Rights[94]—does not comprehensively protect the integrity of one's mental content and processes. Rather, this right is interpreted as a right to mental health and a freedom from mental suffering, anxiety, and indignity in the light of Articles 3 and 8 ECHR.[67,95] This interpretation does not imply the protection of the content of the mind against unsolicited interference or the protection of mental processes against manipulation by third parties.

Considering the unique and unprecedented ways in which neurotechnological developments may impact individuals and society, we have to ask ourselves whether the existing human rights framework offers sufficient protection to the mind. Here, a parallel can be drawn with the concerns that arose with the advent of genetic technologies in the 1990s. At that time, the international community believed that human rights law needed to be updated so as to proactively tackle the challenges that would emerge with increasing interventions into the human genome. This resulted in the adoption of the Universal Declaration on the Human Genome and Human Rights[96] and the International Declaration on Human Genetic Data,[97] where geno-specific human rights are stipulated. Similarly, the question now arises whether neuro-specific human rights—neurorights—should be introduced to better protect our fundamental interests against neurotechnological interference with our mental processes.

Several human rights experts are not in favour of introducing neurorights. They suggest that the human rights framework, consisting of rights such as the right to private life and the right to freedom of thought, is sufficiently flexible to offer an adequate protection against the undesirable effects of neurotechnologies.[98-101] In their view, an evolutive or innovative interpretation of existing human rights can adequately protect against the potential threats posed by neurotechnology. In contrast, several academics and policymakers consider an introduction of neurorights to be necessary and urgent. For instance, Ienca and Andorno state that a satisfactory protection of people's mental sphere, in contrast to their bodily integrity, is lacking in the existing international human rights framework. In response, they suggest complementing the human rights framework with neurorights, including a right to cognitive liberty, a right to mental privacy, a right to mental integrity, and a right to psychological continuity.[67] The introduction of these neurorights at the international level could be accomplished by adding an additional protocol to existing legal instruments or by adopting new dedicated legal instruments.[33] The most fundamental neuroright in their analysis is the right to cognitive liberty. The concept of cognitive liberty was brought into the spotlights in the early 2000s by legal theorist Boire[102] and neuroethicist Sententia.[103] Both academics proposed the recognition of a right to cognitive liberty as "the right and freedom to control one's own consciousness and electrochemical thought processes is the necessary substrate for just about every other freedom" (Sententia, 2004, p. 227).[103]

Other legal experts also argue for the introduction of neurorights, aiming at protecting people's mental privacy, autonomy, authenticity, and identity against threats inherent to unbridled neurotechnological developments. The concept of cognitive liberty sometimes takes on another form and is referred to as the right to mental self-determination or mental integrity (***sensu lato***). In essence, however, these notions all refer to a right that can be understood "as a right against (certain kinds of) non-consensual interference with the mind" (Douglas & Forsberg, 2021, p. 182).[104] Lavazza, for example, puts forth the concept of mental integrity. He defines mental integrity "as the individual's mastery of his mental states and his brain data so that, without his consent, no one can read, spread, or alter such states and data in order to condition the individual in any way" (Lavazza, 2018, p. 4).[76] This definition underlines the privacy aspect to mental integrity as well as the classical integrity aspect ***sensu stricto*** (i.e., freedom from harm). This broad definition acknowledges the strong interconnectedness between integrity, privacy, autonomy, authenticity, and identity as fundamental interests put at risk. Bublitz stated explicitly that the right to cognitive liberty should be "a central legal principle guiding the regulation of neurotechnologies" (Bublitz, 2013, p. 2).[105] He defines this right as "the right to alter one's mental states with the help of neurotools as well as to refuse to do so" (idem).[105] He explicitly attributes a multi-dimensional character to the right to cognitive liberty in the sense that this right envisages the protection of the mind against undue interferences, as well as the liberty of every person to change their mind with whatever means they wish. Together with Merkel, he later introduced the notion of a right to mental self-determination to stress that this right implies the right to determine whether one wants one's mind altered by neurotechnology.[106,107] This brief oversight illustrates that a consensus on the boundaries and terminology of neurorights is currently lacking.[33]

Strong advocates of neurorights can also be found among neuroscientists. The Spanish neuroscientist Yuste, for instance, is a pioneering advocate for neurorights. Recently, Yuste, together with Genser and Herrmann, issued a call to the UN to undertake action to promote and protect neurorights.[35] Such an international approach seems to be the approach favoured by most academics arguing for an increased legal protection of the human mind.[108] Furthermore, Yuste's advocacy directly led to the unique and innovative legislative initiatives recently taken in Chile. The Chilean legislator felt that interests such as mental integrity and mental privacy needed an explicit and effective legal protection in the light of the ongoing ***neurorevolution***. It opted to implement neurorights on two levels. On the one hand, a constitutional amendment that entrenches a right to mental integrity in Article 19 of the Constitution, was unanimously approved in both chambers of the National Congress and signed by the Chilean President on 14 October 2021. The new Article 19 stipulates:

> Scientific and technological development will be at the service of people and will be carried out with respect for life and physical and mental integrity. The law will regulate the requirements, conditions and restrictions for its use by people, and must especially protect brain activity, as well as the information from it.[109]

This constitutional provision establishes a general protection of the right to mental integrity in the light of scientific and technological developments. The original proposal[110] was more elaborated in this regard as it clarified the specific aim of the right to mental integrity, as ensuring the full enjoyment of personal identity and the right to determine one's own actions, without any manipulation by third parties. Furthermore, the new constitutional provision stipulates that restrictions to the use of new technologies must be regulated by law. Together with this constitutional reform, a NeuroProtection Bill was adopted, which explicitly frames this right to mental integrity in the context of neurotechnology and operationalises the constitutional right to mental integrity.[111] The Chamber of Deputies of the Chilean parliament is currently discussing this legislative proposal. The bill aims "to protect the physical and mental integrity of individuals, through the protection of the privacy of neuronal data, the right to autonomy or liberty of individual decision-making, and the right to fair access, without any arbitrary discriminations, to those neurotechnologies that enhance mental capacities".[111] This goal largely corresponds to the five neuro-rights set forth by Goering and Yuste,[92] namely the right to personal identity, the right to free will, the right to mental privacy, the right to equitable access to enhancement technologies, and the right to protection against bias and discrimination. Nonetheless, it is important to stress that the worldwide constitutional first established by the Chilean legislator is met with considerable criticism. Many philosophers, legal scholars, and digital-rights specialists are sceptical about the far-reaching initiative of entrenching neurorights into the national constitution, pointing out that concepts such as 'psychological continuity' need conceptual clarification before they are enshrined into law.[112]

Although the Chilean constitutional reform bill and NeuroProtection bill are the first of this kind, other governmental and intergovernmental actors are also picking up the warnings issued by ethicists and human rights advocates. For example, in 2019, the Organisation for Economic Co-operation and Development (OECD) adopted the *Recommendation on Responsible Innovation in Neurotechnology*[4] which constitutes the first international standard which aims to address the social, ethical, and legal challenges which arise from neurotechnologies. Furthermore, in the same year, the Council of Europe adopted its *Strategic Action Plan on Human Rights and Technologies in Biomedicine,* which acknowledges the need to assess "the relevance and sufficiency of the existing human rights framework to address the issues raised by the applications of neurotechnologies".[113] Similarly, the International Bioethics Committee of the UNESCO drafted a report in 2020, recommending a neuro-oriented chapter to be added to the Universal Declaration on Human Rights, addressing the ethical issues raised be neurotechnology.[114,115] On the national level, Spain adopted a *Charter of Digital Rights* where the protection of fundamental rights and freedoms against neurotechnologies is explicitly addressed.[116]

Conclusion

It is clear that neuroscientific and neurotechnological developments hold the potential to initiate a transformative revolution within our society. These developments provide us with growing insights into the functioning of the brain and might bring us closer to unravelling the mystery of the human mind. Neurotechnological advancements also offer promising prospects for the treatment of disorders which were commonly deemed untreatable (such as Parkinson's Disease and major depression). In this regard, these scientific and technological developments certainly need to be stimulated.

However, granting technology direct access to people's neural processes also holds considerable risks. The human mind may no longer be the last impregnable fortress in which one can find refuge without having to worry about unsolicited interference from the outside world. The increasing readability and influenceability of the mind have to be anticipated, as pressing ethical concerns will arise. As outlined above, the most urgent ethical issues involve threats to mental privacy, autonomy, authenticity, personal identity, the self, and equality or non-discrimination. It is of crucial importance to examine how neurotechnologies could impair these fundamental interests, to which extent this would be so problematic that regulatory intervention is required, and, if needed, how this regulatory protection should be shaped. Admittedly, neuroscientific insights nor neurotechnology itself are today sufficiently advanced to enable severe infringements upon people's mental sphere in daily life. Nevertheless, neurotechnological developments, predominantly taking place in laboratory settings, already clearly indicate their potential to cause violations of fundamental moral values. Proactive anticipation of these luring dangers is of primordial importance to ensure the full enjoyment of the benefits of neurotechnologies in various aspects of life, without risking the violation of fundamental societal and individual interests.

As a result of increasing advocacy by legal experts, neuroscientists, and ethicists, awareness that we need to reflect on normative safeguards is cautiously finding its way to the policy agenda of national and supranational regulatory actors. What started with broad reflections on the need for a right to cognitive liberty to counter growing interference with the functioning of the mind, grew into a vivid debate in neuroethics and neurolaw about the normative significance of neurotechnological threats and the need for regulatory action. Whereas some regulatory actors—such as the OECD and the Chilean legislator—have already taken tentative steps to change regulatory frameworks, a solid consensus on the need for specific regulation and, if so, on the role of improving human rights law, is far from being reached. However, recent collaborations between the Council of Europe, the OECD, and UNESCO, in addition to the growing interest and mobilisation from legal experts, neuroscientists, and ethicists, prove that the unwanted side-effects of neurotechnological developments and the possible inadequacy of current human rights law are finally given proper consideration.

Acknowledgements

This research was supported by the Fund for Scientific Research of Flanders (FWO).

References

[1] Sample I. Mind-Controlled Robotic Suit to debut at World Cup 2014. ***The Guardian*** 2014, April 1 https://www.theguardian.com/technology/2014/apr/01/mind-controlled-robotic-suit-exoskeleton-world-cup-2014. 2.

[2] Jiang L, et al. BrainNet: A Multi-Person Brain-to-Brain Interface for Direct Collaboration Between Brains. ***Sci. Rep.*** 2019;9:6115.

[3] Willet FR, et al. High-performance brain-to-text communication via handwriting. ***Nature*** 2021;593:249–254.

[4] OECD. ***Recommendation on Responsible Innovation in Neurotechnology*** 2019. https://www.oecd.org/science/recommendation-on-responsible-innovation-in-neurotechnology.htm.

[5] Hoyle B. Secret team invent helmet to read the mind. ***The Sunday Times*** 2020, May 11. https://www.thetimes.co.uk/article/secret-team-invent-helmet-to-read-the-mind-3tjtrfx6d.

[6] Rainey S, et al. Brain Recording, Mind-Reading, and Neurotechnology: Ethical Issues from Consumer Devices to Brain-Based Speech Decoding. ***Sci Eng Ethics*** 2020;26:2295-2311.

[7] Farah M.J. ***Neuroethics: an introduction with readings.*** (Cambridge: Massachusetts Institute of Technology, 2010).

[8] Richmond S. Brain imaging and the transparency scenario., in Richmond S, et al. (eds.), ***I know what you're thinking. Brain Imaging and Mental Privacy*** (Oxford: Oxford University Press, 2012):185-204.

[9] Soon CS, et al. Predicting free choices for abstract intentions**.** ***PNAS*** 2013;110(15):6217–6222.

[10] Bode S, et al. Similar neural mechanisms for perceptual guesses and free decisions. ***NeuroImage*** 2013;65:456–465.

[11] Chang L, Tsao DY. The code for facial identity in the primate brain. ***Cell*** 2017;169(6):1013-1028.

[12] Huth AG, et al. Decoding the Semantic Content of Natural Movies from Human Brain Activity. ***Front. Syst. Neurosc.*** 2016;10:81.

[13] Nishimoto S, et al. Reconstructing visual experiences from brain activity evoked by natural movies. ***Curr. Biol.*** 2011;21(19):1641-1646.

[14] Shinkareva SV, et al. Commonality of neural representations of words and pictures. ***NeuroImage*** 2011;54(3):2418-2425.

[15] Wang J, et al. Predicting the brain activation pattern associated with the propositional content of a sentence: Modelling neural representations of events and states. ***Hum. Brain Mapp.*** 2017;38:4865–4881.

[16] Peth J, et al. Memory detection using fMRI—Does the encoding context matter? ***NeuroImage*** 2015;113:164-174.

[17] Saarimäki H, et al. Discrete Neural Signatures of Basic Emotions. ***Cereb. Cortex*** 2016;26(6):2563–2573.

[18] Horikawa T, et al. Neural decoding of visual imagery during sleep. ***Science*** 2013;340(6132):639–642.

[19] Schneiber D, et al. Red Brain, Blue Brain: Evaluative Processes Differ in Democrats and Republicans. ***PLoS One*** 2013;8(2):e52970.

[20] Monti MM, Sannita WG (eds.). ***Brain Function and Responsiveness in Disorders of Consciousness*** (Cham: Springer, 2016).

[21] Owen AM. Detecting Consciousness: A Unique Role for Neuroimaging. ***Annu. Rev. Psychol.*** 2013;64(1):109–133.

[22] Mackey S, et al. Neuroimaging-based pain biomarkers: definitions, clinical and research applications, and evaluation frameworks to achieve personalized pain medicine. ***Pain Rep.*** 2019;4(4):e764.

[23] Eickhoff SB, Lagner R. Neuroimaging-based prediction of mental traits: road to utopia or Orwell? ***PLoS Biol.*** 2019;17(11):e3000497.

[24] Mecacci G, Haselager P. Identifying Criteria for the Evaluation of the Implications of Brain Reading for Mental Privacy. ***Sci. Eng. Ethics*** 2019;25:443–461.

[25] Wolpaw JR, et al. Brain–computer interface technology: a review of the first international meeting. ***IEEE Trans. Rehab. Eng.*** 2000;8(2):164–173.

[26] Mudgal S, et al. Brain computer interface advancement in neuroscience: application and issues. ***Interdiscip. Neurosurg.*** 2020;20:100694.

[27] Huang H, et al. An EEG-based brain-computer interface for automatic sleep stage classification. ***13th IEEE Conference on Industrial Electronics and Applications (ICIEA)*** 2018:1988–1991.

[28] Fadzal CWNFCW, et al. Review of brain computer interface application in diagnosing dyslexia. ***IEEE Control Syst. Grad. Res. Colloq.*** 2011:124–128.

[29] Akcakaya M, et al. Non-invasive brain-computer interfaces for augmentative and alternative communication. ***IEEE Rev. Biomed. Eng.*** 2014;7:31-49.

[30] Wei L, Hu H. Towards multimodal human-machine interface for hands-free control: A survey. ***Technical Report: CES–510***, 2011.

[31] Klein E. Neuromodulation ethics: preparing for brain-computer interface medicine., in Illes J (ed.). ***Neuroethics. Anticipating the future*** (Oxford: Oxford University Press, 2017):123-143.

[32] Soekadar S, et al. Optical brain imaging and its application to neurofeedback. *Neuroimage Clin.* 2021;30(2):102577.

[33] Committee on Bioethics of the Council of Europe. *Common Human Rights Challenges Raised by Different Applications of Neurotechnologies in the Biomedical Field* 2021. Report drafted by Ienca M. https://rm.coe.int/report-final-en/1680a429f3.

[34] Haynes JD. Brain reading., in Richmond S, et al. (eds.). *I Know What You're Thinking: Brain Imaging and Mental Privacy* (Oxford: Oxford University Press, 2012):29-40.

[35] Yuste R, Genser J, Herrmann S. It's Time for Neuro-Rights; New Human Rights for the Age of Neurotechnology. *Horizons* 2021;18:155-164.

[36] Macduffie KE, Goering S. Neurotechnologies Cannot Seize Thoughts: A Call for Caution in Nomenclature. *AJOB Neurosci.* 2019;10(1):23-25.

[37] Poldrack R. *The new mind readers* (Princeton: Princeton University Press, 2018).

[38] Zuk P, Lazaro-Munoz G. Ethical Analysis of "Mind Reading" or "Neurotechnological Thought Apprehension": Keeping Potential Limitations in Mind. *AJOB Neurosci.* 2019;10(1):32-34.

[39] Roskies A. Mind Reading, Lie Detection and Privacy., in Clausen J, Levy N (eds.). *Handbook of neuroethics* (Dodrecht: Springer, 2015):679-695.

[40] Klein E. Ethics and the emergence of brain-computer interface medicine., in Ramsey NF, Millan JR (eds.). *Handb. Clin. Neurol.* 2020;168:329-339.

[41] Lee DJ, et al. Current and future directions of deep brain stimulation for neurological and psychiatric disorders. *J. Neurosurg.* 2019;131(2):333-342.

[42] Pycroft L, et al. Deep Brain Stimulation: An Overview of History, Methods and Future Developments. *Brain and Neurosci. Adv.* 2018;2(10):1-6.

[43] Schiff ND, et al. Behavioural improvements with thalamic stimulation after severe traumatic injury. *Nature* 2007;448:600-603.

[44] Tan SZK, et al. The paradoxical effect of deep brain stimulation on memory. *Aging Dis.* 2020;11(1):179-190.

[45] Elias G, et al. Probabilistic mapping of deep brain stimulation: insights from 15 years of therapy. *Ann. Neurol.* 2021;89:426-443.

[46] Johansson V, et al. Thinking ahead on deep brain stimulation: an analysis of the ethical implications of a developing technology. *AJOB Neurosci.* 2014;5(1):24-33.

[47] Graat I, et al. The application of deep brain stimulation in the treatment of psychiatric disorders. *Int Rev Psychiatry* 2017;29(2):178-190.

[48] Reinhart RM, Nguyen JA. Working Memory Revived in Older Adults by Synchronizing Rhythmic Brain Circuits. *Nature Neurosci.* 2019;22(5):820-827.

[49] Latorre A, et al. The Use of Transcranial Magnetic Stimulation as a Treatment for Movement Disorders: A Critical Review. *J. Mov. Disord.* 2019;34(6):769-782.

[50] Terranova C, et al. Is There a Future for Non-invasive Brain Stimulation as a Therapeutic Tool? *Front. Neurol.* 2019;9:1146.

[51] Yue ZSE, et al. Controlled delivery for neuro-bionic devices. *Adv. Drug Deliv. Rev.* 2013;65(4):559-569.

[52] Parastarfeizabadi M, Kouzani A. Advances in closed-loop brain stimulation devices. *J. Neuroeng. Rehabilitation* 2017;14:79.

[53] Ghasemi P, et al. Closed- and Open-loop Deep Brain Stimulation: Methods, Challenges, Current and Future Aspects. *J. Biomed. Phys. Eng.* 2018;8(2):209–216.

[54] Towne C, Thompson KR. Overview on research and clinical applications of optogenetics. *Curr. Protoc. Pharmacol.* 2016;75:11.19.1–11.19.21.

[55] Delbeke J, et al. And Then There Was Light: Perspectives of Optogenetics for Deep Brain Stimulation and Neuromodulation, *Front. Neurosc.* 2017;11:663.

[56] Jarrin S, Finn DP. Optogenetics and its application in pain and anxiety research. *Neurosci Biobehav Rev* 2019;105:200-211.

[57] Jarvis S, Schultz SR. Prospects for optogenetic augmentation of brain function. *Front. Syst. Neurosc.* 2015;9:157.

[58] Zawadski P, Adamczyk AK. Personality and authenticity in light of the memory-modifying potential of optogenetics. *AJOB Neurosci.* 2021;12(1):3-21.

[59] Hildt E. Electrodes in the brain: Some anthropological and ethical aspects of deep brain stimulation. *IRIE* 2006;5:33-39.

[60] Leentjes A, et al. Manipulation of mental competence: An ethical problem in case of electrical stimulation of the subthalamic nucleus for severe Parkinson's disease. *NTvG* 2004;148(28):1394-1398.

[61] Schüpbach M, et al. Neurosurgery in Parkinson disease: A distressed mind in a repaired body? *Neurology* 2006;66(12):1811–1816.

[62] Witt K, et al. Neuropsychological and psychiatric changes after deep brain stimulation for Parkinson's disease: A randomised, multicentre study. *Lancet Neurol.* 2008;7(7):605–614.

[63] Nuffield Council of Bioethics. *Novel neurotechnologies: intervening in the brain* 2013. https://www.nuffieldbioethics.org/assets/pdfs/Novel-neurotechnologies-report.pdf.

[64] Yuste R, et al. Controlling Visually Guided Behavior by Holographic Recalling of Cortical Ensembles. *Cell* 2019;178(2):447-457.

[65] The Royal Society. *iHuman Blurring lines between mind and machine* 2019. https://royalsociety.org/topics-policy/projects/ihuman-perspective/.

[66] Wexler A. Do-it-yourself and direct-to-consumer neurostimulation. *Developments in Neuroethics and Bioethics* 2020;3:127-155.

[67] Ienca M, Andorno R. Towards new human rights in the age of neuroscience and neurotechnology. *Life Sci. Soc. Policy* 2017;13(5):1–27.

[68] Dana Foundation. *Mind and matter ethical challenges of deep brain stimulation—Edited transcript* 2008, http://www.dana.org/WorkArea/showcontent.aspx?id=14006.

[69] Beauchamp TL, Childress JF. *Principles of bioethics, 7th edition* (Oxford: Oxford University Press, 2013).

[70] Bublitz JC. Privacy Concerns in Brain-Computer Interfaces. *AJOB Neurosci.* 2019;10(1):30-32.

[71] Lai CH. Promising Neuroimaging Biomarkers in Depression. *Psychiatry Investig.* 2019;16(9):662-670.

[72] Shimizu S, et al. Role of Neuroimaging as a Biomarker for Neurodegenerative Diseases. *Front. Neurol.* 2018;9:265.

[73] Jayarathne I, et al. BrainID: Development of an EEG-Based Biometric Authentication System. *IEEE 7th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)* 2016:1-6.

[74] Farah M, et al. Brain imaging and brain privacy: a realistic concern? *Journ. Cogn. Neurosci.* 2010;21(1):119-127.

[75] Ienca M, Haselager P. Hacking the brain: brain-computer interfacing technology and the ethics of neurosecurity. *Ethics inf. Technol.* 2016;18(2):117-129.

[76] Lavazza A. Freedom of Thought and Mental Integrity: The Moral Requirements for Any Neural Prosthesis. *Front. Neurosci.* 2018;12:82.

[77] Gilbert F. Deflating the "DBS causes personality changes" bubble. *Neuroethics* 2021;14(2):1-17.

[78] Witt K, et al. Deep brain stimulation and the search for identity. *Neuroethics* 2013;6(3):499-511.

[79] Foley P. Deep brain stimulation for Parkinson's Disease: historical and neuroethical aspects., in Clausen, J, Levy N (eds.). *Handbook of neuroethics* (Dodrecht: Springer, 2015):561-581.

[80] Klaming L, Haselager P. Did My Brain Implant Make Me Do It? Questions Raised by DBS Regarding Psychological Continuity, Responsibility for Action and Mental Competence. *Neuroethics* 2013;6(3):527–539.

[81] Müller S, Christen M. Deep brain stimulation in parkinsonian patients—Ethical evaluation of cognitive, affective, and behavioral sequelae. *AJOB Neurosci.* 2011;2(1):3–13.

[82] Gilbert F, et al. I Miss Being Me: Phenomenological Effects of Deep Brain Stimulation. *AJOB Neurosci.* 2017;8(2):96-106.

[83] Widge A, et al. Predictors of hypomania during ventral capsule/ventral striatum deep brain stimulation. *J. Neuropsychiatry Clin. Neurosci.* 2015;28(1):38–44.

[84] Klein E, et al. Brain-computer interface-based control of closed-loop brain stimulation: attitudes and ethical considerations. *Brain-Comput. Interfaces* 2016;3(3):1-9.

[85] Ligthart S, et al. Closed-Loop Brain Devices in Offender Rehabilitation: Autonomy, Human Rights, and Accountability. *Camb Q Healthc Ethics* 2021;30(4):669-680.

[86] Friedrich O, et al. An Analysis of the Impact of Brain-Computer Interfaces on Autonomy. *Neuroethics* 2021;14(3):17-29.

[87] Kellmeyer P. Ethical and Legal Implications of the Methodological Crisis in Neuroimaging. *Camb Q Healthc Ethics* 2017;26(4):530–554.

[88] Rainey S, Erden YJ. Correcting the brain? The convergence of neuroscience, neurotechnology, psychiatry and artificial intelligence. *Sci Eng Ethics* 2020;26(2):2439-2454.

[89] Rickli JM, Ienca M. The security and military implications of neurotechnology and artificial intelligence., in Friedrich O, et al. (eds.). *Clinical Neurotechnology meets Artificial Intelligence* (Cham: Springer, 2021):197-214.

[90] Lavazza A. Thought Apprehension: The "True" Self and The Risks of Mind Reading. *AJOB Neurosci.* 2019;10(1):19-20.

[91] Erler A. Neuroenhancement, coercion and neo-Luddism., in Vincent NA, et al. (eds). *Neurointerventions and the law* (Oxford: Springer, 2020):375-405.

[92] Yuste R, Goering S, et al. Four ethical priorities for neurotechnologies and AI. *Nature* 2017;551:159-163.

[93] Ienca M. On Neurorights. *Front. Hum. Neurosc.* 2021;15:485.

[94] ECtHR 3 June 2004 Bati a.o. v. Turkey, App. Nos. 33097/96 and 57834/00; ECtHR July 2006 Jalloh v Germany, App. No. 54810/00; ECtHR 24 July 2012 Dordevic v. Croatia, App. No. 41526/10; In other cases the court refers to the right to psychological integrity, e.g. ECtHR 20 March 2007 Tysiac v. Poland, App. No. 5410/03; ECtHR 26 May 2011 R.R. v Poland, App. No. 27617/04.

[95] Peers S. et al. (eds.). *The EU Charter of Fundamental Right* (Oxford: Hart Publishing, 2019):46-47.

[96] United Nations. *Universal Declaration on the Human Genome and Human Rights* 1997.

[97] UNESCO. *International Declaration on Human Genetic Data* 2003.

[98] Algre S. Rethinking Freedom of Thought for the 21st Century. *E.H.R.L.R.* 2017;3:221-223.

[99] Ligthart SLTJ, et al. Forensic brain-reading and mental privacy in European human rights law: foundations and challenges. *Neuroethics* 2021;14(2):191-203.

[100] Michalowski S. Critical Reflections on the Need for a Right to Mental Self-Determination., in Von Arnauld A, et al. (eds.). *The Cambridge handbook of new human rights* (Cambridge: Cambridge University Press, 2020):404-411.

[101] Nawrot O. What about the interior castle? Response to Ienca's and Andorno's new human rights in the age of neuroscience and neurotechnology. *Roczniki Teologiczne* 2019;66(3):70-85.

[102] Boire R.G. Cognitive Liberty Part 1, *J. Cogn. Lib.* 2000;1(1):7-13.

[103] Sententia W. Neuroethical Considerations: Cognitive Liberty and Converging Technologies for Improving Human Cognition. *Ann. N. Y. Acad. Sci.* 2004;1013:221-228.

[104] Douglas T & Forsberg L. Three Rationales for a Legal Right to Mental Integrity., in Ligthart S. et al. (eds.). *Neurolaw. Advances in Neuroscience, Justice & Security* (Basingstoke: Palgrave Macmillan, 2021):179-201.

[105] Bublitz JC. My Mind is Mine!? Cognitive Liberty as a Legal Concept., in Hildt E, Franke AG (eds.). *Cognitive Enhancement: An Interdisciplinary Perspective* (Dodrecht: Springer, 2013):233-264.

[106] Bublitz JC, Merkel R. Crimes Against Minds: On Mental Manipulations, Harms and a Human Right to Mental Self-Determination. *Crim. Law Philos.* 2014;8(1):51-77.

[107] Bublitz JC. The nascent Right to Psychological Integrity and Mental Self-Determination., in Von Arnauld A, et al. (eds.). ***The Cambridge handbook of new human rights*** (Cambridge: Cambridge University Press, 2020):387-403.

[108] See for example the call from Sommagio and colleagues for the introduction of a Universal Declaration on Neurorights; Sommagio P, et al. Cognitive Liberty and Human Rights., in D'Aloia A, Errigo MC. ***Neuroscience and Law; Complicated Crossings and New Perspectives*** (Cham: Springer, 2020):95-113.

[109] Ley 25 Octubre de 2021 Núm. 21.383, Modifica La Carta Fundamental, Para Establecer El Desarrollo Cientifico Y Technológico Al Servicio De Las Personas. https://static1.squarespace.com/static/60e5c0c4c4f37276f4d458cf/t/6182c0a561dfa17d0ca34888/1635958949324/English+translation.pdf.

[110] In the original proposal, the new Article 19 of the constitution stipulated the following: "The physical and mental integrity allows people to fully enjoy their individual identity, and the right to act in a self-determined manner. No authority or individual may, by itself or through any technological mechanism, increase, decrease or disturb that individual integrity. Only the law may establish the requirements to limit this right, and the requirements that consent must fulfil in these cases."; 7 octobre 2020, Boletín N° 13.827-19 Proyecto de reforma constitucional, iniciado en moción de los Honorables Senadores señor Girardi, señora Goic, y señores Chahuán, Coloma y De Urresti, que modifica el artículo 19, número 1°, de la Carta Fundamental, para proteger la integridad y la indemnidad mental con relación al avance de las neurotecnologías: p. 14. https://www.senado.cl/appsenado/templates/tramitacion/index.php?boletin_ini=13827-19.

[111] Proyecto de ley 7 octubre 2020, iniciado en moción de los Honorables Senadores señor Girardi, señora Goic, y señores Chahuán y De Urresti, sobre protección de los neuroderechos y la integridad mental, y el desarrollo de la investigación y las neurotechnologies.

[112] Strickland E. Worldwide Campaign for Neurorights Notches its First Win. Chile Plans to Regulate All Neurotech and Ban the Sale of Brain Data. ***IEEE Spectrum*** 2021, December 18. https://spectrum.ieee.org/neurotech-neurorights.

[113] Council of Europe. ***Strategic Action Plan on Human Rights and Technologies in Biomedicine 2020-2025*** 2020. https://rm.coe.int/strategic-action-plan-final-e/1680a2c5d2.

[114] UNESCO International Bioethics Committee. ***Draft Report of the IBC on Ethical Issues of Neurotechnology*** 2020. https://unesdoc.unesco.org/ark:/48223/pf0000375237.

[115] On the basis of the instruments mentioned in [4, 112, 113], the COE, the OECD, and UNESCO on 9 November 2021 collectively organised the round-table event "Neurotechnologies and Human Rights Framework: Do We Need New Rights?" in which experts in the field of neurorights shared their views on the future direction for regulating neurotechnological developments.

[116] Carta Derechos Digitales 2021. https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/140721-Carta_Derechos_Digitales_RedEs.pdf.